

THE WAR AND NEW BRITISH INDUSTRIES

IMPERIAL INSTITUTE MONOGRAPHS

OIL SEEDS AND FEEDING CAKES

WITH A PREFACE BY

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PREFACE

It may be of interest to record the origin of the monographs of which the first series is included in the present volume. For a number of years, in fact since its re-establishment in 1908 under Government control, the Imperial Institute has devoted its chief energies to the investigation of the sources and industrial uses of raw materials of every description, and to the maintenance of reference collections of such materials derived from the Colonies and India. It has collected and critically arranged existing information respecting the sources and industrial employment of all well-known materials. It has conducted experimental tests of a great variety of new or little-known materials in its laboratories and workshops, and has thus created new technical information on these subjects. A large staff, both scientific and technical, has been constantly employed on this work, dealing chiefly with materials derived from British countries overseas. The Institute has initiated and maintained communication with manufacturers and users of raw materials, through whose invaluable assistance industrial employment

has been found in this country for a number of important products of our Colonies and India.

The successful development of the work of a Department with expert knowledge of the sources and uses of raw materials necessitates close touch on the one hand with the Colonies and India as sources of many materials new or little known, and with the manufacturers and users of such materials at home. The Department, in fact, has aimed at being the link between these two important elements of industrial enterprise, and its work has year by year steadily grown in amount and importance.

The principal results of this work, so far as they can be published, are to be found in the quarterly *Bulletin of the Imperial Institute* (John Murray), and in the Technical Reports which have been periodically presented to Parliament and issued as Government publications. These publications are necessarily technical in their nature and naturally appeal for the most part to those connected with production overseas and with utilisation at home. Such reports can scarcely be expected under ordinary circumstances to appeal to the general public.

The sudden outbreak of a great European war has, however, roused general interest in the serious industrial problems with which our tropical possessions, as well as our manufacturers, were unexpectedly confronted, and it has therefore been decided to issue these monographs, which to-day command a wider interest than before. Whilst

written primarily for those immediately concerned, these monographs reveal a condition of affairs as regards the past and possibilities for the future which it is essential should be generally recognised and their importance realised by the nation as a whole, and especially by those who are immediately interested in the development of commercial relations within the Empire.

Just before the war an important extension of the work of the Imperial Institute had been arranged. By the formation of a Technical Information Bureau the increasing demands for technical information respecting raw materials could be more readily and efficiently met than was possible so long as the collection and arrangement of a vast amount of information and the replies to inquiries had to be attended to by the staff of the Scientific and Technical Department. For this Department was also responsible for those numerous experimental investigations entailed by the technical examination of new or little-known materials, the results of which form the subject of the several hundred reports which are annually sent to the countries concerned, whilst it also conducted collateral correspondence with manufacturers at home.

The inauguration of the new Bureau was most opportune, for since the war it has been overwhelmed with inquiries and problems sufficient to occupy the entire energies of twice as large a staff as that at present assigned to it. The information respecting the utilisation of raw materials in foreign countries which had been already collected

has proved of immense service at the present juncture.

India and the Colonies were anxious to find new markets for raw materials which had hitherto gone almost exclusively to Germany and other foreign countries, and for which there was now no longer any outlet. In these cases the Imperial Institute at once took action by issuing circulars to all British manufacturers likely to be interested, summarising the origin, value and uses of the materials in question, and offering assistance in conducting special tests, solving industrial problems, and in supplying introductions to producers overseas who were ready to supply.

British manufacturers almost wholly dependent on Germany and other foreign countries for necessary raw or partially manufactured materials have inquired for new sources of these, and also for precise information as to their quality and prices. This information the Imperial Institute has usually been able to supply at once, and also to provide introductions to producers at home or overseas. In some cases, as in those dealt with in this volume, complete arrangements for utilising the materials are not at present in existence, and some time must elapse before the new source of supply can be fully made use of.

Although the same condition is found to some extent in other countries, it must be admitted that we in this country have allowed virtually the entire supply of certain important British raw materials to be utilised by foreign countries, and have been

satisfied to purchase from those countries the manufactured products we required. It is clear that in many instances these raw materials might have been profitably dealt with in this country, the surplus only being exported.

It is, however, only fair to add that it is strongly held by some that tariff arrangements in other countries and preferential shipping rates and Government subsidies have contributed in no small measure to this state of affairs.

The monographs contained in the present volume have been selected to illustrate in detail important cases in which at the outbreak of war exports of certain materials from our Colonies and India became impossible. These materials had hitherto gone either to a belligerent country or to a foreign country which formerly traded with a country now belligerent, and which was no longer able to dispose of the manufactured product, and consequently unable to continue to purchase the raw material. It was therefore necessary to ascertain whether industrial uses could be found in this country for the materials in question.

Copra

An exceedingly important source of vegetable oil is copra, the dried fleshy interior of the coconut. The oil is extracted by pressure, and is solid except at the higher temperatures of the tropics. The residual cake is a nutritious feeding-stuff for animals. Copra is one of the principal exports of

the British tropics, and while a certain amount has come to Great Britain and to France, far larger amounts have been taken by Germany and Austria, especially from India, Ceylon, and the Federated Malay States. On the outbreak of war these countries found difficulty in disposing of all their copra. The export to Germany and Austria had been about 150,000 tons, valued at about £3,250,000. The large trade with Germany is chiefly the result of the assiduity shown by the German agents who organised it in the British tropics. The Imperial Institute, soon after the outbreak of war, brought the situation to the notice of the principal British firms interested in copra or likely to be so, with the result that arrangements have been made to utilise a considerable proportion of the copra formerly sent to Germany and Austria, for which purpose certain manufacturers are extending their plant. Co-operation was also arranged with the Board of Agriculture in order to draw further attention to the merits of coconut cake as a food for cattle.

The effectiveness of the action taken may be to some extent judged from the figures recently published by the Ceylon Chamber of Commerce, which show that in 1914 the exports of copra to London from Ceylon alone amounted to 562,500 cwts., whilst in 1912 these were only 1,500 cwts.

Palm Kernels

The monograph on the Palm Kernels of West Africa illustrates a typical situation. These kernels

are contained in the nuts of the well-known oil palm- (*Elaeis guineensis*), abundant especially on the littoral of British West Africa, and are the source of a solid fat which is an oil at tropical temperatures. This is not only valuable for soap-making, but has recently acquired additional importance as an edible fat, and as an important constituent of margarine and the "vegetable butters" which are now so largely consumed in all countries. The statistics given will show that the largest purchaser of these kernels was Germany.

The kernels were shipped to Hamburg, where, by the operation technically known as crushing or pressing, the oil is squeezed out of the crushed kernels by mechanical pressure. The residue from which the oil has been expressed is known as the "cake," owing to the shape of the compressed residue as it leaves the oil press; or when powdered, or when the oil has been extracted by a chemical solvent instead of by pressure, as "meal." The palm-kernel oil was partly consumed in Germany, but also largely exported to England. The value of about a quarter of a million tons of palm kernels exported to Germany from British West Africa in 1912 was £3,800,000. The cake was largely consumed in Germany, where its merits as a feeding-stuff for cattle were well recognised.

So far little crushing of palm kernels had been carried on in England, the chief reason being that the cake was not recognised by our farmers to be as satisfactory as other feeding materials

for live stock, and hence a profitable market for the palm-kernel cake, an essential condition of industrial success, was not to be found in this country. This country could only make use of the palm-kernel oil, and this was chiefly purchased from Germany. Commercial subsidies given by Germany are stated also to have operated against the successful establishment of the industry in this country. The palm kernels of British West Africa therefore went to Germany and there formed the basis of an important oil-pressing industry. The German-pressed oil was purchased by other countries and largely by England. The palm-kernel cake was either retained in Germany or exported to neighbouring countries as a valuable food for animals. In the few years immediately preceding the war, relatively small quantities of palm kernels had been shipped to this country. The amount of oil pressed here was small, and the attempts made to utilise the cake were in their infancy—so much so that in one instance at least palm-kernel cake made in England had been burnt because no remunerative market could be found for it. The industry in this country had reached no considerable dimensions when war was declared in the summer of 1914, and the position then was that there was no market for the great majority of West African kernels which formerly had been shipped to Germany. The few oil mills in England which had already begun to take small quantities of kernels were not in a position to make larger purchases, especially in view of the difficulty there would be in disposing of the cake.

An article on the subject was at once published in the *Bulletin of the Imperial Institute*, summarising the facts as to the industrial uses of palm kernels in Germany, and suggesting action by English manufacturers, and a circular was issued by the Technical Information Bureau of the Imperial Institute to all the principal oil manufacturers in England calling their attention to this article.

The Institute also co-operated with the Board of Agriculture in compiling a pamphlet (*see Appendix*) on the feeding value of palm-kernel cake, which was widely distributed to farmers throughout the country. The question of disposing of the stocks of kernels which had accumulated in West Africa was energetically taken up by the West African Section of the London Chamber of Commerce under the chairmanship of Sir Owen Philipps, who reprinted as a special pamphlet, together with other information, the article on palm kernels which had appeared in the *Bulletin of the Imperial Institute*.

Palm-kernel cake has now been issued for trial as a feeding-stuff to the Agricultural Colleges throughout England, and satisfactory reports as to its suitability for feeding cattle are already coming in. It is likely to answer best in this country when used in admixture with other feeding-stuffs. With a prospect now in view of finding in this country a market for the cake, English oil pressers are purchasing the kernels, and more than one firm is extending its works in order to include palm kernels in its operations in the future. The foundations have therefore been laid for the establishment of

the palm-kernel oil and cake industry in this country. In this case German competition after the war will be confronted with the difficulty that the regular export of kernels to this country will have been established, so far as British West Africa is concerned, whilst the loss of the German Colonies in West Africa cuts off another possible source of supply. Any attempted artificial interference with the industry, such as subsidies or preferential shipping rates to Hamburg, will no doubt in future be met by appropriate Government action in this country. A discriminating export duty or the prohibition of the export of palm kernels from West Africa except under special licence might be considered necessary.

It therefore appears that if Germany is to carry on this industry in the future, it may only be possible by the purchase of palm kernels from French Colonies or from the Belgian Congo. France has hitherto not taken any great interest in palm kernels for the reason that its industrial centres, chiefly Marseilles and Bordeaux, are already sufficiently supplied with other sources of vegetable oil. Belgium had intended to utilise in that country some portion of the palm kernels from the Congo, and in the future this enterprise may be resumed. It is clear, however, that the present is a great opportunity for the permanent establishment of a large and important industry in England.

Ground Nuts

In another monograph the similar case of ground

nuts is described, where, however, the actual situation is somewhat different. The kernels of these nuts, which are contained in a soft crinkled shell, are commonly called "monkey nuts" in this country, "*arachides*" in France, and "peanuts" in America. These nuts are an even more valuable source of food than palm kernels. The refined oil which they furnish closely resembles olive oil, and is very largely employed on the Continent for similar purposes, and also for the manufacture of vegetable butters and margarine. The crude oil, as it issues from the nuts when pressed, is principally used in soap-making, and is now employed in making the well-known white soap of Marseilles, which at one time was made only from olive oil. The nuts themselves, especially if carefully selected and prepared, serve as cheap substitutes for almonds in confectionery, and are also capable of being adapted for other edible purposes, since their nutritive value is very high. The cake left after the oil has been extracted forms an excellent food for cattle, and is asserted to be of particular value for milch cows. The ground nut is grown throughout the tropics, though the nuts grown in different localities exhibit considerable difference in quality. The French Colony of Senegal in West Africa is noted for the excellence of the ground nuts produced there, the entire crop of which goes to Marseilles, where the oil is pressed, contributing to the great edible and soap-making industries of that important centre.

For some years France, and chiefly Marseilles,

has taken ground nuts from other tropical countries, including the large output ($1\frac{1}{4}$ million cwts., in 1918 valued at over half a million sterling) of the British West African Colony of the Gambia, which, like its French neighbour Senegal, produces a large crop of fine quality. As will be seen from the figures given, the Gambia crop goes almost entirely to Marseilles. India, too, has contributed nearly the whole of her enormous output of ground nuts (over $5\frac{1}{2}$ million cwts. in 1918, valued at over £8,000,000) to the same French port, which in fact has absorbed nearly all the ground nuts which the world can offer, with the exception of those grown in the United States for local consumption. So far as British countries are concerned the case is similar to that of palm kernels, only that whilst palm kernels were taken by Germany, ground nuts have been taken by France. The industrial utilisation of ground nuts, like that of palm kernels, cannot be made financially successful unless a remunerative market can be found for the residual cake, left after the expression of the oil. The oil produced in Marseilles finds a ready market in France—where, however, there is only a limited market for the cake, owing to the abundance of other foods for live stock. It will be observed from the figures given that the cake has been readily taken by Germany, where it is much esteemed, especially as a food for milch cows.

One of the first results of the war was that the great export of ground-nut cake from Marseilles to Hamburg became impossible, and the French

manufacturers were no longer able to dispose satisfactorily of this residue, the export of which even to neutral countries was prohibited by the French Government, although this is now permitted in strictly limited quantities to certain countries under rigid guarantees as to destination. The mills were obliged greatly to diminish production, and nearly the whole of the output of India and the Gambia was without an outlet.

Having regard to the fact that the greater part of the cake had hitherto been taken by Germany, it was obvious that relief could not be found without a new market either for the cake or for the nuts themselves. In the meantime the enormous output of India remaining unshipped caused some uneasiness. At the suggestion of the Indian Trade Commissioner in London, the Imperial Institute took action in the matter, and the information respecting ground nuts now summarised in the accompanying monograph was issued as a circular to all the principal oil-seed pressers in this country.

Hitherto ground nuts have been little used in England. A certain quantity is shipped here in shells and sold for edible purposes, and a small quantity of the kernels is used in confectionery. The oil, and especially the cake, are but little known in this country. There appears, however, to be no reason why such an important product of India and the Colonies should not be utilised here. The new enterprise will take time to develop, especially as it will involve to some extent the replacement of other well-known feeding cakes,

such as those of linseed and cotton seed, which are at present in favour with British farmers, and are largely imported from abroad.

With the object of relieving the immediate difficulty in India and the Gambia, and with the desire to assist our Ally France, the French Government was approached with a view to permitting the export of ground-nut cake to this country. In order to obtain first-hand knowledge of the situation I visited Marseilles; interviewed the chief manufacturers and merchants, and obtained a large amount of information respecting the French oil seed industry. Some manufacturers of feeding-stuffs in this country were willing to take supplies for use in admixture with other materials in making "compound" cakes, whilst certain firms of oil pressers were ready to take trial shipments of ground nuts from India. The way has therefore been paved for the utilisation of the ground nut in this country. There is no desire to interfere with the already established industry in France, but, apart from the closing of German markets, the increasing production of ground nuts in the tropics renders an extension of their utilisation in Europe very desirable. At present, and probably for some time to come, France will not be able to take anything like so large a proportion of the ground nuts of the world as she has done, chiefly owing to the absence of a satisfactory market for the enormous quantity of cake which it will be seen from the figures now given formerly went to Germany. The ground nut

enterprise in Marseilles as well as the collateral industries there are also now confronted with further and more serious difficulties in this connection, owing to the Italian labour, upon which these industries have almost entirely depended since the French mobilisation, being no longer available owing to the mobilisation of Italy.

It is clearly desirable that the increasing output of ground nuts from our own tropical possessions should in future in large part be utilised by our own manufacturers. This is expedient on account of the further large increase which is likely to occur in their production in the British tropics. The ground nut plant is not only profitable on account of the value of its nuts for export and for local use. A leguminous plant, it has the power of fixing the nitrogen of the air and rendering it available in the soil as plant food. In the rotation of crops in the tropics, and especially in connection with cotton cultivation, the growth of ground nuts is of immense importance. The present crusade in their favour, which has been started by the Imperial Institute, may therefore have far-reaching results.

The assistance of the Board of Agriculture has been invoked in making the merits of the cake better known to the British farmer. The value of the oil will, it is hoped, cause a further demand for it among British manufacturers of edible oils and margarine, whilst, as is indicated in the monograph, the consumption of the prepared nuts for eating might well be extended in this country, as it has been in the United States.

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Sesame Seed

The fourth monograph of the present series deals with sesame or "til" seed (*Sesamum indicum*), another important tropical oil seed which is largely grown in India, Egypt, the Sudan and elsewhere. Like ground nuts, these seeds furnish an edible oil and a cake of great value as a food for animals. Hitherto the crushing and pressing of the seeds has been conducted chiefly in France and the cake exported to Germany. The oil is a well-known substitute for olive oil, and is a recognised component of margarine. In the great extension of the British vegetable oil and cake industries which is now taking place, sesame seed should play an important part, as the increased production of these seeds and their profitable utilisation will be of benefit to India and to several British countries in the tropics.

Mowra Seed

The last monograph relates to the "mowra" and other similar Indian seeds of species of *Bassia*, which furnish a solid fat largely used for cooking by the natives in India. At a time when solid edible fats are in great demand it is desirable to draw attention to this seed, of which it would appear that India might export considerable quantities. These seeds are utilised to some extent in France, but the cake has not so far been regarded as a satisfactory feeding-stuff.

The remarkable position which the vegetable oil industry and its dependencies has now attained, owing chiefly to the increased consumption of vegetable oil in the form of margarine, renders it necessary for this country to take its part in activities which have been conspicuous in recent years throughout the continent of Europe, but for the moment are checked by the war. The production of margarine and other similar preparations, which is growing to large dimensions, the increased manufacture of soap and the production of feeding-stuffs for animals—all these important industries depend upon the utilisation of oil seeds which are products of our own tropical possessions, and which it is clear can be made the basis of profitable industries in our own country.

The principal centres in this country to which we look for important extensions of these industries are Liverpool, London, and Hull, where large factories are already established. The extensions now projected call for the use of additional capital, and probably of additional shipping facilities. The utilisation of some of the seeds now referred to has hitherto been rendered difficult owing to there having been until recently no direct shipment of these seeds to the port of Hull. Virtually the whole of the palm kernels exported to this country from West Africa have been carried to Liverpool or Hamburg. This year, however, the first direct shipment of palm kernels from West Africa to Hull has been made. The extension of the Hull industry is important, as there may be a

large outlet in the agricultural districts of Yorkshire for palm-kernel cake, whilst Hull has facilities for export of the surplus to Scandinavia where there is a large market.

With the kind permission of the Board of Agriculture there is reprinted as an Appendix to this volume Special Leaflet No. 20 on Coconut Cake and Palmnut Kernel Cake.

As I have laboured for nearly twenty years to demonstrate the importance to the Empire of a Government Department scientifically and technically equipped to assist British industrial enterprise in dealing with the great questions connected with the utilisation of the raw materials of our Empire, and especially the undeveloped raw materials of our tropical possessions, I may be allowed to express my gratification at the important part which the Imperial Institute has been able to play in the present industrial emergency. This success is to be attributed to the persistent organisation of work in which scientific, technical and commercial investigations each occupy a well-defined place in one and the same establishment, which directs its efforts to solving the initial problems of industrial enterprise, efforts which are now recognised as of value not merely to British industry at home, but to British activities throughout the tropics.

The war has brought with it the more general recognition of the supreme importance of Government assistance in these directions, so contrived as to avoid the extremes of unspecialised academic science on the one hand, and on the other the mere

collection and publication of facts and figures. The initiation of new industries and the development of existing industries raise problems in the solution of which many British manufacturers have been able to derive material assistance from the Imperial Institute.

WYNDHAM R. DUNSTAN.

IMPERIAL INSTITUTE,
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OIL SEEDS AND FEEDING CAKES

COPRA

THE important article of commerce known as copra consists of the dried fleshy kernel of the coconut. It is produced in large quantities in all countries in which the coconut palm grows, but chiefly in Ceylon, Southern India, the Netherland East Indies, British Malaya and the Philippines. The methods of preparing copra are briefly as follows. The outer fibrous husk (the coir from which mats are made) which envelopes the hard shell of the coconut is first removed. This is usually effected by striking the coconut on to the pointed end of a hard piece of wood or iron bar fixed firmly in the ground. A few sharp blows, followed by twists on the part of the operator, loosens the husk, which is then pulled off by hand. The husked nut is next split in two by cutting through the hard shell and kernel with a hatchet. The watery contents (so-called milk) are drained away and the halves are placed on a clean piece of sandy ground fully exposed to the sun, with their hollow sides uppermost. After a few hours' exposure, the portions of the kernel left in the halved nuts shrink sufficiently to allow of their being readily removed from the shells, and the

OIL SEEDS AND FEEDING CAKES

separation of shells and kernels is the next operation. The kernels are further exposed to the sun for several days, being frequently turned at short intervals, until sufficiently dry to be baled for export. Copra prepared in this manner is known on the market as "sun-dried" copra, and if carefully and quickly made from thoroughly ripe nuts is usually of good quality. In order to expedite the drying process, the kernels, after being removed from the shells, are sometimes placed on tables of sheet iron protected from rain, or on a "grille" made of green wood or bamboo, over a fire of coconut shells. By this treatment drying is completed in from twenty-four to thirty-six hours, but frequently the copra becomes blackened owing to contact with smoke from the fire, and has a smoky smell, in consequence of which its market value is lowered. Copra prepared in this manner is known as "kiln-dried," "smoke-dried" or "smoked" copra. During recent years specially constructed copra-drying houses and machines have come into use, fitted with heating plant which maintains a current of hot, dry air, in which the kernels are exposed. The drying process is completed in a few hours by means of these contrivances, and copra of high quality is produced. This is known in commerce as "hot-air dried" copra. The care bestowed on the preparation of copra has considerable influence on the products subsequently derived from it, therefore clean, carefully prepared copra fetches the highest price on the market. If

properly prepared from ripe nuts, copra is greyish-white, and free from dirt and mould, and of an agreeable nut-like odour. Copra imperfectly dried is liable to the attacks of fungi, which cause discoloration and deterioration; it then has an unpleasant, often black appearance, is soft and frequently of disagreeable odour. If kept dry, carefully prepared copra will remain in good condition for a long time.

The table on page 4 shows, so far as the figures are available, the quantities and values of the exports of copra from the principal producing countries, and also gives some idea of the importance of copra as an article of trade. It will be seen that of British countries Ceylon is the largest producer, and one of the three largest producers in the world.

The market value of copra varies somewhat according to the country of origin, the methods employed in its preparation, its appearance and quality. In the table which follows are enumerated the principal commercial grades and also recent market quotations in London and Marseilles:

	London (June 14, 1915) Per ton.			Marseilles (May 17, 1915) Per 100 kilos.
	£	s.	d.	Fr.
Malabar .	23	10	0	68.00
Ceylon .	22	15	0	—
Singapore and Penang .	22	0	0	—
Zanzibar .		—		65.00
Manila .	21	2	6	63.75
South Sea .	21	0	0	—
Mozambique .	21	15	0	65.00

EXPORTS OF COPRA

	Year.	Quantity.	Value.
<i>British Territories :</i>		cwt.	£
Ceylon	1913	1,117,292	1,397,284
India	1913-14	763,832	1,039,826
Federated Malay States . .	1913	185,753	211,043
Seychelles	1914	72,269	78,774
Tongan Islands Protectorate	1913	68,520	72,480
Fiji	1913	158,585	176,741
Papua	1913-14	24,020	26,063
British Solomon Islands . .	1912-13	83,920	73,637
Gilbert and Ellice Islands Protectorate	1911	41,700	20,700
East Africa Protectorate . .	1913-14	31,725	35,587
Zanzibar	1914	199,563	193,574
Gold Coast	1913	12,589	14,291
Trinidad	1913	10,308	11,545
<i>Foreign Territories :</i>			
Philippine Islands	1913	1,618,080	1,988,692
Java	1913	1,556,000	
Sumatra (East Coast) . . .	1912	80,860	
Celebes	1913	580,340	
Indo-China	1912	157,074	95,783
New Caledonia	1912	53,173	64,850
French Oceania	1912	117,662	112,569
Samoa	1912	220,423	203,496
Bismarck Archipelago, Ger- man Solomon Islands, and German New Guinea	1912	223,814	202,603
East Carolines, Marshall Is- lands and Nauru	1912	94,910	82,820
West Carolines, Pelew and Mariana Islands	1912	21,706	15,091
German East Africa	1912	83,468	78,172
Portuguese East Africa . . .	1911	78,820	48,066

THE TRADE IN COPRA, COCONUT OIL AND
CAKE

The largest purchasers of copra before the outbreak of war were Germany (whose supplies for

the most part were obtained from British Possessions) and France; considerable quantities were also taken by Austria-Hungary and by Belgium. Since the outbreak of war the markets of Germany and Austria-Hungary have been closed, leaving a large surplus of British copra to be absorbed by other markets. It appears desirable, therefore, to direct the attention of merchants and manufacturers in the United Kingdom to this condition of affairs with a view to the further development of the market for copra in this country, and the extension of those manufactures in which coconut oil is a raw material.

The distribution of the copra exported from British Possessions is shown in the tables which follow:

CEYLON

	1911		1912		1913	
	cwts.	£	cwts.		cwts.	£
United Kingdom	10,503	9,382	9,996	10,804	1,500	2,001
India .	56	27	—	—	163	244
Austria-Hungary	12,096	13,120	29,977	31,956	30,041	37,518
Belgium .	14,508	14,439	4,020	2,445	18,000	23,422
Denmark	11,500	14,133	68,000	79,285	25,667	34,639
France .	7,999	7,934	2,000	2,200	1,003	1,000
Germany	567,473	612,312	368,034	408,525	814,979	1,013,486
Holland .	1,000	1,000	1,000	1,067	1,059	1,200
Roumania	—	—	—	—	4,000	5,600
Russia .	191,171	200,341	131,042	135,893	220,880	278,174
United States .	5,508	5,500	—	—	—	—
TOTAL	821,814	878,188	614,089	672,175	1,117,292	1,397,284

OIL SEEDS AND FEEDING CAKES

INDIA

	1911-12		1912-13		1913-14	
	cwts.	£	cwts.	£	cwts.	£
United Kingdom	40,814	51,805	43,999	54,318	7,040	9,308
British Possessions .	847	834	753	852	758	1,002
Russia .	31,485	36,373	43,184	54,886	73,047	98,056
Germany .	473,392	563,168	548,331	687,142	479,797	657,628
Holland .	12,735	15,866	8,492	10,258	16,747	21,822
Belgium .	25,485	29,718	13,904	15,889	100,914	138,135
Franco .	48,490	56,920	26,049	32,367	68,219	91,464
Other countries	4,375	4,914	2,281	3,153	17,310	22,411
TOTAL .	637,523	759,658	686,993	858,865	763,832	1,039,826

STRAITS SETTLEMENTS (1913)

	Singapore.		Penang.	
	cwts.	£	cwts.	£
United Kingdom .	75,773	93,348	12,882	16,780
Austria-Hungary .	27,093	33,414	—	—
Belgium . . .	19,063	22,921	6,045	7,579
Denmark. . .	86,065	113,601	74,182	95,805
France . . .	203,298	239,967	8,994	11,690
Germany . . .	632,302	810,856	307,373	394,051
Russia . . .	288,104	349,746	56,004	73,480
Other countries .	32,409	37,994	1,003	1,273
TOTAL . . .	1,364,107	1,701,847	466,483	600,658

The exports from the Straits Settlements are mainly re-exports from the Federated Malay States, the Protected Malay States, British North Borneo, the Netherland East Indies, the Philippine Islands and Siam.

COPRA

SEYCHELLES

	1912.		1913.		1914.	
	cwts.	£	cwts.	£	cwts.	£
United Kingdom	799	813	10,521	14,127	5,420	5,101
France . . .	46,083	46,619	44,106	52,772	51,202	52,706
Germany . . .	6,963	5,981	2,368	2,757	279	332
Other countries .	—	—	1,743	2,263	15,368	20,625
TOTAL .	53,845	53,413	58,738	71,919	72,269	78,774

MAURITIUS

	1911.		1912.		1913.	
	cwts.	£	cwts.	£	cwts.	£
United Kingdom	—	—	145	68	763	860
France . . .	37	5	22	18	—	—
Germany . . .	—	—	—	—	1,192	1,080
TOTAL .	37	5	167	86	1,955	1,940

TONGAN ISLANDS PROTECTORATE (FRIENDLY ISLANDS)

	cwts.	£
1910 . . .	259,960	232,866
1911 . . .	254,420	231,479
1912 . . .	222,400	209,567
1913 . . .	68,520	72,480

Details as to the destination of the exports in 1911, 1912 and 1913 are not given in the official returns for these Islands, but in 1910 about one-quarter of the total output was shipped to Europe, the balance going to Australia, with the exception

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of a small quantity which was exported to New Zealand. The decrease in 1913 was due to the plantations having been severely damaged by a hurricane.

FIJI

	1911.		1912.		1913.	
	cwts.	£	cwts.	£	cwts.	£
United Kingdom .	—	—	49,099	45,354	34,747	36,518
Australia .	257,814	233,915	207,841	180,780	122,352	138,063
New Zealand	68,916	60,330	16,230	14,899	—	—
Canada .	—	—	1,040	1,040	—	—
United States	—	—	—	—	1,483	1,557
Japan .	—	—	—	—	3	3
TOTAL .	326,730	294,245	274,210	242,073	158,585	176,741

PAPUA

Details as to the destination of the copra exported from Papua are not given in the official returns. The quantities and values of the exports in recent years are as follows :

	cwts.	£
1910-11 . .	21,204	17,837
1911-12 . .	19,860	19,368
1912-13 . .	15,880	16,356
1913-14 . .	24,020	26,063

BRITISH SOLOMON ISLANDS

The total exports of copra from the British Solomon Islands in recent years are as follows ; the countries of destination are not given in the

official returns, but they are believed to be chiefly British :

		cwts.	£
1910-11	.	80,600	68,999
1911-12	.	71,740	55,953
1912-13	.	83,920	73,637

GILBERT AND ELLICE ISLANDS PROTECTORATE

The estimated total exports of copra in 1910 amounted to 60,000 cwts., valued at £30,000. In 1911 the exports were 41,400 cwts., valued at £20,700. Details are not available as to the destination of the exports.

EAST AFRICA PROTECTORATE

	1911-12.		1912-13.		1913-14.	
	cwts.	£	cwts.	£	cwts.	£
United Kingdom	403	412	405	468	1,814	2,300
Zanzibar . .	3,534	2,966	3,624	3,620	3,891	4,191
France . .	27,780	24,677	26,524	27,151	24,479	26,864
Germany . .	—	—	368	381	1,060	1,441
Other countries.	—	—	362	336	481	701
TOTAL .	31,717	28,055	31,283	31,956	31,725	35,587

ZANZIBAR

	1913		1914	
	cwts.	£	cwts.	£
United Kingdom .	—	—	148	930
India . .	—	—	252	218
France . .	187,297	215,063	198,960	192,278
Germany . .	1,728	1,779	203	148
TOTAL .	189,025	216,842	199,563	193,574

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The above amounts for 1914 include re-exports amounting to 31,406 cwts., valued at £31,284, derived mainly from German East Africa. The copra of Zanzibar is usually of poor quality and the expressed oil is used in France for soap making.

GOLD COAST

	1911.		1912.		1913.	
	cwts.	£	cwts.	£	cwts.	£
United Kingdom .	54	30	99½	69	45	39
France . . .	13,950	11,987	11,617	11,256	12,394	14,136
Germany . . .	1,593	1,234	679	514	150	116
United States .	—	—	2½	2	—	—
TOTAL . . .	15,597	13,257	12,398	11,841	12,589	14,291

NIGERIA

	1911.		1912.		1913.	
	cwts.	£	cwts.	£	cwts.	£
United Kingdom .	2	1½	28	28	203	203
French possessions	1,740	1,542	825	740	—	—
Germany . . .	196	129	1,041	861	1,732	1,688
TOTAL . . .	1,938	1,672½	1,894	1,629	1,935	1,891

TRINIDAD

	1911.		1912.		1913.	
	cwts.	£	cwts.	£	cwts.	£
United Kingdom .	10,068	8,772	9,323	10,138	7,979	8,936
Germany . . .	3,523	3,216	13,101	12,298	1,637	1,834
United States .	1,249	1,276	5,793	6,290	692	775
TOTAL . . .	14,840	13,264	28,217	28,726	10,308	11,545

JAMAICA

	1911.		1912.		1913.	
	cwts.	£	cwts.	£	cwts.	£
United Kingdom .	199	263	408	610	608	604
Germany .	—	—	4	5	—	—
United States .	—	—	10	10	23	4
TOTAL .	199	263	422	625	631	608

BRITISH GUIANA

	1912.		1913.	
	cwts.	£	cwts.	£
United Kingdom .	1,143	1,101	1,063	1,337
British West Indies .	1½	1½	—	—
United States .	4½	5	64	89
TOTAL .	1,149	1,107½	1,127	1,426

A few other British Possessions also export small quantities of copra.

The following table shows the total quantities of copra imported into Germany and Austria-Hungary in 1913:

IMPORTS OF COPRA IN 1913 TO GERMANY AND AUSTRIA-HUNGARY

	Quantity metric tons (2,204 lb.).
<i>Germany :</i>	
Imports from all sources . . .	196,449
„ „ British Possessions	85,764
<i>Austria-Hungary :</i>	
Imports from all sources . . .	33,604
„ „ British Possessions	29,177

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The details of the imports from the British Empire are as follows :

IMPORTS OF COPRA TO GERMANY AND AUSTRIA-HUNGARY IN 1913 FROM THE BRITISH EMPIRE

	Germany, ¹ metric tons (2,204 lb.).	Austria-Hungary, metric tons (2,204 lb.).
British Africa .	507	774
British East Indies.	84,683	22,104
Australia . . .	574	6,299
TOTAL .	85,764	29,177

Of the total quantity imported into Austria-Hungary, 608 metric tons are said to come from British Australia and 5,691 metric tons simply from Australia. The latter in all probability include imports from countries in the Pacific other than Australia proper.

From the tables given above it will be seen that about 115,000 metric tons of copra from British Possessions, which before the outbreak of war went to Germany and Austria-Hungary, are now available for other markets. In addition there is the quantity formerly taken by Belgium, which, so far as the details given in the preceding tables show, amounted to 3,125 metric tons from British Possessions in 1913.

The European market most capable of expansion appears to be that of the United Kingdom, as there exists here already a large demand for coconut oil

¹ Exclusive of re-exports.

for various manufacturing purposes. In addition to the amount of coconut oil imported by the United Kingdom from British Possessions, some 30,236 metric tons were imported from Germany in 1913 and 18,600 metric tons from other foreign countries. These amounts are exclusive of the import of manufactures of coconut oil such as margarine, vegetable butter and other edible fats of various kinds which are imported in large quantities. The coconut oil import of the United Kingdom from foreign countries corresponds with about 82,000 metric tons of copra, or considerably more than half the quantity of British copra that went to Germany and Austria-Hungary before the outbreak of war. It would seem, therefore, that this amount might be readily dealt with in the United Kingdom. A serious difficulty, however, stands in the way of this expansion in the absence of a local market for the coconut cake. As has been already stated, coconut cake is used to a far greater extent on the Continent, particularly in Germany, than is the case in this country, and in order to develop the copra-crushing industry it seems essential to spread amongst British farmers a better knowledge of the value of the cake as a cattle food, with a view to its more extensive use. Complete statistics as to the trade in coconut cake are difficult to obtain, as coconut cake is not always distinguished from other oil-cakes in Trade Returns. In a report on an investigation into the competitors of cotton-seed products in Northern Europe, recently conducted on behalf of the

United States Government by Mr. E. W. Thompson (*Special Agents Series: No. 84, Bureau of Foreign and Domestic Commerce, U.S. Department of Commerce*), there are some interesting particulars as to the trade. From this report it appears that 71,000 metric tons of coconut cake were produced in Germany in 1912, of which amount 30,000 tons were consumed locally. The Trade Returns for Ceylon show that in 1913 the export of coconut cake amounted to 236,692 cwts., of which 157,895 cwts., valued at £45,629, were sent to Germany, and 73,606 cwts., valued at £25,677, to Belgium. The export of coconut cake from India in 1912-13, according to the Trade Returns, amounted to 128,074 cwts., valued at £41,463, practically the whole of which was sent to Germany. The report above referred to also states that about 12,000 tons of coconut cake were produced in the United Kingdom, 8,000 tons of which were exported; the Netherlands produced 9,400 tons and exported 5,000 tons; Denmark produced 10,500 tons, nearly the whole of which was exported. The Marseilles production in 1912 is estimated at about 64,000 tons, only a small quantity of which was exported. These particulars, therefore, tend to confirm what has been said as to the extensive use of coconut cake on the Continent as compared with the United Kingdom.

The next largest consumer of copra is France, and it is possible that larger quantities of British copra might be absorbed by that country. In 1913 the import of copra into France amounted to

112,640 metric tons, 17,366 tons of which came from British Possessions, 8,832 tons from French Colonies, 37,956 tons from the Netherland East Indies, and 40,051 from the Philippines. In view of the superior quality of much British copra, it should be possible for it to compete successfully with copra from the Netherland East Indies and the Philippines for the French market. The market in Holland is supplied chiefly from the Dutch Colonies, and it would probably be difficult for British copra to obtain a very large market in Holland. The United States market is supplied for the most part from the Philippines, which in 1913 contributed 10,674 metric tons to the total United States import of 15,548 metric tons, the balance being drawn for the most part from French, British, and what were formerly German possessions in the Pacific. The other markets in which there appears to be a possibility of expanding the copra trade are those of Sweden, Norway, and Denmark (which are already large consumers of coconut oil), and Russia.

The alternative to finding a larger European market for copra appears to be to increase the local production by modern methods of coconut oil in such countries as India and Ceylon, where already this industry is on a large scale, and to initiate the copra-crushing industry in those countries that at present export copra only. This alternative, while maintaining the supply of coconut oil for manufacturing purposes in Europe, would have the advantage of creating locally large

supplies of a valuable cattle food, and of increasing the amount and fertilising value of locally produced animal manures, both of which are of great importance in all tropical countries.

COCONUT OIL

The chief value of copra is as a source of coconut oil, and it is to obtain this oil that copra is imported into the manufacturing countries of Europe and the United States of America. Large quantities of coconut oil are also produced in tropical countries, especially in India and Ceylon, chiefly by primitive native methods, but also now in modern oil mills. An idea of the importance of the trade in coconut oil in India and Ceylon may be formed from the particulars given in the tables on the opposite page, which show the quantities and values of the exports, and also the countries to which they are sent.

The chief grades of coconut oil are known in commerce as "Cochin oil," "Ceylon oil" and "Copra oil." The term "Cochin" was originally applied to high-grade oil prepared on the Malabar coast of Madras by boiling fresh coconut kernels with water, and separating the oil by skimming. Oil prepared from fresh kernels is now produced in other countries, and the term "Cochin" is applied to these irrespective of locality. "Ceylon oil" is often obtained by the Cochin method, but owing either to less care being bestowed on its preparation, or to climatic conditions, it is often inferior in quality to Cochin oil obtained from the

EXPORTS OF COCONUT OIL FROM INDIA

Importing countries.	1911-12.		1912-13.		1913-14.	
	gals.	£	gals.	£	gals.	£
United Kingdom . . .	557,292	72,076	217,655	29,499	223,756	31,759
British Possessions . . .	59,117	8,133	48,174	6,811	30,132	4,687
Sweden . . .	316,295	40,998	99,385	13,217	119,541	16,996
Germany . . .	584,251	65,469	103,940	20,929	161,632	22,857
Holland . . .	60,306	7,772	39,337	5,017	29,283	4,116
Belgium . . .	34,506	4,507	46,229	6,189	43,571	6,212
United States . . .	477,487	62,080	327,899	43,644	447,664	63,070
Other foreign countries . . .	75,849	9,777	26,875	3,715	35,898	5,376
TOTAL .	2,165,103	270,812	969,494	129,021	1,091,477	155,073

EXPORTS OF COCONUT OIL FROM CEYLON

Importing countries.	1911.		1912.		1913.	
	cwts.	£	cwts.	£	cwts.	£
United Kingdom . . .	258,064	448,868	167,586	294,393	150,650	307,326
British Possessions . . .	2,120	3,679	1,789	3,143	2,261	4,612
Austria-Hungary . . .	16,253	28,204	17,975	31,576	14,300	29,172
Belgium . . .	10,247	17,782	2,804	4,926	4,407	8,990
France . . .	119	206	—	—	5	10
Germany . . .	16,960	29,431	5,306	9,321	1,712	3,493
Holland . . .	2,038	3,537	1,441	3,531	3,116	6,357
India (other than British) . . .	952	1,652	1,092	1,918	1,203	2,454
Italy . . .	852	1,478	2,046	3,694	2,311	4,715
Mozambique . . .	3,001	5,208	441	775	276	563
Norway . . .	12,072	20,949	31,423	55,200	40,626	82,877
Russia . . .	—	—	—	—	401	818
Sweden . . .	3,998	6,938	3,779	6,638	3,411	6,958
United States . . .	177,731	308,422	166,053	291,700	322,305	657,502
Other foreign countries . . .	9	16	44	77	—	—
TOTAL .	505,016	876,370	401,779	705,792	546,984	1,115,847

Malabar coast. The Ceylon coconut oil obtained in mills by modern methods of expression is usually of first-rate quality and commands a high price. The native-prepared oil is sometimes "sun-extracted," the kernels in this case being sliced up or pounded and then placed in vessels fully exposed to the sun, which liquefies the oil and causes it to exude into vessels placed to receive it. Much of the ordinary coconut oil of India and Ceylon is produced by means of the primitive native oil-mill of the pestle and mortar type, worked by oxen. This latter method of expressing the oil may be termed the "cold dry" process, as contrasted with the "hot wet" process obtaining on the Malabar coast. "Copra oil" is produced on a large scale in modern oil mills in Europe, and to a smaller extent in the United States and in Australia. In this case the copra is first reduced to a meal by grinding with special machinery, and is then subjected to pressure at a temperature of 55° to 60° C.

The quality of the coconut oil is naturally influenced by the character of the copra from which it is obtained. "Hot-air-dried" copra and carefully prepared "sun-dried" copra yield oils of high quality with a paler colour than those obtained from "kiln-dried" copra, whilst imperfectly dried or mouldy copra yields an oil that is not only acid, but also contains other impurities, which give it an unpleasant taste and smell. The yield of oil obtained depends upon the ripeness of the nuts and the thoroughness with which the copra has

been prepared. From hot-air-dried copra as much as 74 per cent. of oil has been obtained; from kiln-dried copra from 60 to 65 per cent.; whilst from sun-dried copra the yield is only about 50 per cent. The price of London expressed coconut oil is £33 10s. per ton (June 1915).

The best coconut oil is a solid milk-white fat at ordinary temperatures in Europe. In the tropics it is liquid, and it is on this account that it is usually spoken of as coconut "oil" and not as coconut "fat." The oil has a pleasant taste and a nut-like odour, and if well prepared does not rapidly become rancid. Inferior qualities are usually more or less discoloured and, if derived from low-grade or smoked (*i.e.* kiln-dried) copra, are usually rancid and disagreeable in taste.

Uses of Coconut Oil

In India and the East generally, coconut oil is largely used for cooking. It was formerly also employed as an illuminant, but has now been displaced to a large extent by mineral oil. In France it is largely employed in the preparation of pomades and similar articles, but its more important use in Europe is for the manufacture of soap and margarine. It is said to have become first known in Europe in the eighteenth century, but it was not till the following century that it came into general use for soap-making, for which purpose it is now used on a very large scale. Still more recently it has been employed in the preparation of so-called vegetable butters,

and for making edible fats used by chocolate manufacturers, biscuit bakers and confectioners. For edible purposes only high-grade oil is employed, and this is first refined so as to eliminate any acid and substances of unpleasant odour. Some of the liquid constituents of the oil are also removed so as to produce a firm fat. The liquid portion or "coconut olein" is employed for soap-making, and the firmer portion or "coconut stearin" for the manufacture of edible fats. The "stearin" of inferior grades of coconut oil is used in the manufacture of candles and night-lights.

COCONUT CAKE

An important by-product of coconut oil manufacture is the residual cake that remains after the oil has been expressed from copra. This is known as "coconut cake" in England and as "poonac" in the East. The quality of the cake varies with the quality of the copra from which it has been derived and the method of expression adopted. The cake from native oil mills usually retains a higher percentage of oil than that turned out by modern oil mills. The higher grades of cake form a valuable cattle food which may be given to stock either as cake or after being reduced to meal by grinding. The inferior grades are used as manure. Coconut cake of good quality is greyish-brown in colour; it possesses an agreeable taste and smell, and is readily eaten by cattle. Hitherto it has not been used on a very large scale by British farmers, but on the Continent it is

extensively employed as a cattle food, particularly in Germany, where, owing to its relatively high price, it is generally given only to milch cows.

The composition of English-made coconut cake is shown in the following table, and for purposes of comparison the constituents of some of the commoner feeding cakes in use in this country are also given :

CRUDE NUTRIENTS

	Mols- ture.	Crude pro- teins.	Fat.	Carbo- hydrates (by dif- ference).	Crude fibre.	Ash.	Nutrient ratio.	Food units.
	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.		
Coconut cake, English (ex- pressed) ¹ . .	8.5	24.5	8.3	39.8	12.8	6.1	1 : 2.42	122
Linseed cake, Eng- lish made, avor- age (expressed) ²	11.16	29.50	9.50	35.54	9.10	5.20	1 : 1.94	133
Linseed meal (extracted) ² . .	13.15	34.75	3.03	34.67	8.75	5.65	1 : 1.20	129
Decorticated cot- ton-seed meal, Atlantic ports (expressed) ² . .	7.40	42.37	10.16	25.86	7.06	7.15	1 : 1.16	157
Undecorticated cotton-seed cake, English made (expressed) ² . .	13.75	24.62	6.56	29.28	21.19	4.60	1 : 1.67	107

¹ Analysis made by the Agricultural Analyst for the County of Wilts (1912).

² Smettham (*Journ. Roy. Lancs. Agric. Soc.*, 1914).

By an "expressed" cake is meant one from which the oil has been removed by mechanical pressure. An "extracted" meal is the result of removing the oil more completely by means of a chemical solvent. The term meal, however, is sometimes applied to the ground cake, as in the

case of the American decorticated cotton-seed meal referred to in the foregoing table.

The constituents are seen to comprise: (1) moisture, which is present to the extent of about 10 per cent. and should not be higher than 14 per cent. in cakes of good quality; (2) crude proteins, consisting of nitrogenous substances, the chief function of which, as a food, is to supply material for the formation of flesh; (3) fat, which is used to maintain heat in the animal body and may also be converted into animal fat; (4) carbohydrates, such as starch, sugar, and mucilage, which supply animal heat and energy, and if present in large quantities may become animal fat; (5) crude fibre, composed of more or less indigestible matter, chiefly cellulose; and (6) ash, comprising lime, potash, phosphoric acid, etc., which are essential to the proper nutrition of animals, and which are usually present in sufficient quantities in oil-cakes. The different constituents thus have varying functions to perform in the animal economy, some of which are more important than others, and in estimating the feeding value of an oil-cake it is necessary to take this into consideration. The food units shown in the above table are calculated for the purpose of comparing the total feeding value of one oil-cake with that of another by means of a simple numerical ratio. To arrive at the food units, a unit of value is assigned to each of the several constituents of a cake according to the importance of the function it has to perform; for example, as a food, fat is

two and a half times as valuable as carbohydrates, weight for weight. The food value of a cake may therefore be expressed in food units by adding to the percentage of carbohydrates present, two and a half times the sum of the percentages of fat and crude proteins (Cf. *Board of Agriculture Leaflet, No. 74*).

The digestibility of the constituents of oil-cakes has also to be taken into account in estimating their food values, and as the digestibility of similar substances in different cakes varies somewhat, this point has also to be considered; for example, the proteins of cotton-seed cake and of linseed cake are different, and their degree of digestibility also differs, consequently they have different food values. In cases where the percentage of crude fibre is high, the whole of the digestible constituents present in an oil-cake are not available as food.

In calculating the food value of a cake on the

DIGESTIBLE NUTRIENTS¹

	Crude proteins.	Fat.	Carbo-hydrates.	Crude fibre.	Food units.
	Per cent.	Per cent.	Per cent.	Per cent.	
Coconut cake, English (expressed)	19.1	8.1	33.0	8.1	76
Linseed cake, English made, average (expressed)	25.37	8.74	27.72	2.01	75
Linseed meal (extracted)	29.19	2.88	28.45	4.7	67
Decorticated cotton-seed meal, Atlantic ports (expressed)	36.44	9.55	17.33	1.98	77
Undecorticated cotton-seed cake, English made (expressed)	18.06	6.1	15.23	3.8	46

¹ Calculated from the analyses shown in the preceding table, using the digestibility coefficients of Kellner (*The Scientific Feeding of Animals*, 1909, pp. 387, 388).

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basis of the digestibility of its constituents, the proteins and carbohydrates are considered of equal value and the fat as two and a half times as valuable, whilst for every 3 per cent. of crude fibre present a deduction of one unit is made from the total. This is represented in food units by adding together the percentages of digestible proteins, carbohydrates and fibre, and two and a half times the percentage of fat, and deducting from the total one unit for every 3 per cent. of crude fibre present.

The preceding table shows the favourable position occupied by coconut cake when compared with other feeding cakes from the point of view of the digestibility of its food constituents.

It is important to notice that coconut cakes made in English oil-mills are superior to those made in Germany in containing a comparatively small amount of crude fibre. The analyses of two samples of English coconut cake and a typical sample of German cake are shown in the following table :

	English.		German. According to Kellner (<i>loc. cit.</i>).
	1. Per cent.	2. Per cent.	Per cent.
Moisture	8.5	9.85	10.5
Crude proteins	24.5	23.00	21.4
Fat	8.3	8.00	8.5
Carbohydrates	39.8	44.23	38.7
Fibre	12.8	9.22	14.7
Ash	6.1	5.70	6.2

The analyses of the English cakes have been supplied by the makers of the cakes : No. 1 was made by the Agricultural Analyst

for the County of Wilts in 1912; No. 2 is a factory analysis. Samples of British-made coconut cakes may be seen in the Reference Collection of Standard Commercial Products in the Public Exhibition Galleries of the Imperial Institute.

Numerous feeding experiments to ascertain the value of coconut cake as a food for live-stock have been carried out in Germany and also in the United Kingdom and elsewhere. The results of the German trials show that coconut cake tends to increase milk secretion when it is given to milch cows and goats (Hansson, *Fühlings Landw. Zeit.*, 1912, **61**, 237, *Landw. Vers. Stat.*, 1909, **71**, 370). The English trials carried out at the South-Eastern Agricultural College at Wye, and at the Midland Agricultural and Dairy College, Derby, have, however, not confirmed these conclusions, but showed, on the contrary, that when coconut cake replaced other concentrated foods the yield of milk was slightly decreased. Although a smaller yield of milk resulted, it was found at the Derby trials that the live weight of the animals increased during the period when coconut cake was used as food, and that the butter was better flavoured and of firmer texture than when linseed and cotton-seed cakes were used. This effect on the butter has been confirmed by experiments at Wye and in Germany, and it is an important point, as it indicates that coconut cake is a useful foodstuff to employ for dairy cattle during warm weather, or for counteracting the effect of such foods as crushed oats and maize, wheat bran, rice meal, rape, sesame and sunflower-

seed cakes, all of which tend to produce soft butter. The quantity of coconut cake fed to milch cows should not exceed $4\frac{1}{2}$ lb. to 5 lb. a head per day, otherwise a hard butter with a flavour of tallow is said to result. In California the dairymen are said to be in favour of coconut cake as a food for milch cows (*Rep. Agric. Exp. Stn. California*, 1895-96). As a fattening food for cattle, experiments carried out by the Edinburgh and East of Scotland Agricultural College have shown that it may be fed at the rate of about 4 lb. per head per day without detriment to the animals or to the quality of the meat (see also p. 111).

Ground into meal, coconut cake forms a valuable food for fattening pigs, and as it tends to produce a firm bacon, it is useful for counteracting the effect of those foods which result in an oily bacon. It is used on a large scale in Ireland for pig feeding, but its comparatively high price is against its being profitably employed for this purpose (*Journ. Dept. Agric., Ireland*, 1910-11, 11, 303). As a food for horses it has been shown by experiments carried out by the French War Department, and also by experiments on yearlings and heavy-work horses in the United States, that coconut meal can replace an equal weight of oats in a ration without any adverse effect (*U.S. Dept. of Agric. Bur. of Anim. Ind. Circ.* 168, 1911).

In comparing the cost of different oil-cakes it is important to take into consideration not only their food values, but also the indirect value of

the manures that result from their consumption by animals. The net price per food unit may be ascertained by deducting from the current price of the cake the estimated value of the manure produced, and dividing the remainder by the number of food units calculated on the basis of digestibility (see table, p. 23).

Calculations made in this way are shown in the following table, where the cost per food unit of coconut cake is compared with that of other oil-cakes in common use :

	Current value per ton.	Estimated value of manurial residues arising from the consumption of 1 ton of feeding-stuff.	Cost per food unit, per ton, calculated on the net value, i.e. the current value less the estimated value of the manurial residues.
Coconut cake, English made	£7 7s. 6d. to £7 10s. according to quantity (London, April 1915)	£1 14s. 7d.	1s. 5½d. to 1s. 6½d.
Linseed cake, English made	£11 15s. to £12 15s. (Liverpool, March 1915)	£2 4s. 4d.	2s. 6½d. to 2s. 9½d.
Decorticated cotton-seed cake, English made	£11 to £11 10s. (Liverpool, March 1915)	£3 4s. 9d.	2s. 0½d. to 2s. 1¾d.
Undecorticated cotton-seed cake, English made	£6 17s. 6d. to £7 5s. (Liverpool, March 1915)	£1 15s. 4d.	2s. 2½d. to 2s. 4½d.

PALM KERNELS

THE palm kernel is obtained by shelling the nut of the African oil-palm (*Elaeis guineensis*). The nuts are surrounded by the pericarp or outer pulpy layer of the fruit (the source of palm-oil) which has first to be removed.

In addition to palm oil and palm kernels, the African oil-palm is the source of a large number of economic products—the leaves are used by the West African natives in building huts, the very young leaves as a vegetable, and the palm wine, produced by the fermentation of the juice extracted from the growing bud of the tree, as a beverage. Only palm oil and palm kernels are exported to Europe. For a full description of the oil-palm and its useful products, see the *Agricultural and Forest Products of British West Africa*, by G. C. Dudgeon—Imperial Institute Handbooks (John Murray).

The oil-palm is indigenous to West Africa, but dense forests of the tree are only found in the coastal region. For commercial purposes the present sources of palm kernels are Nigeria, Sierra Leone, Gold Coast and Gambia (British Possessions); French Congo, Dahomey, Ivory Coast, Guinea, Senegal and Gaboon (French Possessions); the Belgian Congo; the former German colonies of the Cameroons and Togoland (now in Anglo-French

occupation); Liberia and Portuguese West Africa. The oil-palm, however, also occurs to a small extent in Central and Eastern Africa, as well as in Brazil, Guiana, the West Indies and Mexico, and it has been planted in various parts of the East Indies.

In West Africa the oil-palm has not so far been cultivated to any large extent, the natives depending entirely on wild trees for their supplies of palm fruit, from which to extract palm oil and kernels. According to competent authorities there are in West Africa enormous areas covered by oil-palms which are not yet utilised.

THE TRADE IN PALM KERNELS

The importance of palm kernels to British Colonies and the magnitude of the trade, which until the last few years has been almost entirely with Germany, will be apparent from the following tables :

EXPORTS OF PALM KERNELS FROM BRITISH WEST AFRICA NIGERIA

	1911.		1912.		1913.	
	Tons.	£	Tons.	£	Tons.	£
United Kingdom . .	22,884	318,943	25,491	365,401	30,345	511,541
Germany . .	145,783	2,166,106	140,036	2,175,736	131,886	2,405,624
Holland . .	7,503	86,290	14,433	181,639	5,984	80,008
South Africa . .	219	3,066	4,664	74,575	5,309	96,593
France . .	—	—	—	—	1,200	16,052
TOTAL .	176,389	2,574,405	184,624	2,797,411	174,720	3,109,820

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SIERRA LEONE

	1911.		1912.		1913.	
	Tons.	£	Tons.	£	Tons.	£
United Kingdom	9,654	140,433	8,846	140,963	1,685	117,904
Germany . . .	33,238	507,915	41,904	652,210	43,016	803,038
Other countries.				5		
TOTAL	42,892	657,348	50,750½	793,178	49,201	920,942

GOLD COAST

	1911.		1912.		1913.	
	Tons.	£	Tons.	£	Tons.	£
United Kingdom	2,430	30,967	2,772	37,548	2,600	41,685
Germany . . .	10,110	135,187	11,079	157,322	6,405	105,613
France . . .	714	9,736	768	10,370	738	11,829
Other countries.	—	—	10	125	—	—
TOTAL	13,254	175,891	14,029	205,365	9,743	159,127

GAMBIA

	1911.		1912.		1913.	
	Tons.	£	Tons.	£	Tons.	£
United Kingdom	443	4,756	445	6,518	545	9,026

The following table, showing the imports of palm kernels into Germany in recent years, will furnish a good idea of the value of the former trade with that country.

IMPORTS OF PALM KERNELS TO GERMANY

	Metric tons.	
1912	261,408	4,966,350
1918	235,917	4,482,400

Information received at the Imperial Institute from oil-seed crushers in this country shows that additional British firms are starting to work palm kernels here. The small consignments of kernels to this country have hitherto been to Liverpool, but arrangements have now been made to ship the kernels direct from West Africa to Hull, the first consignment reaching the latter port in January of this year.

During the first two months of 1915 the quantity of kernels imported into Liverpool amounted to 30,703 tons as compared with an average import of 4,480 tons during the same periods of the last three years.

It is therefore clear that a large proportion of the palm kernels produced in British West Africa will now be utilised in Great Britain.

PALM-KERNEL OIL

From palm kernels two products are obtained: oil or fat (palm-kernel oil), and feeding cake and meal. The cake is the residue remaining after the oil has been removed by crushing, whilst the meal is usually obtained by extracting the ground kernels with a solvent. As the kernels contain

a large amount of fat—from 45 to 50 per cent.—a single crushing is not sufficient to obtain the whole of the oil; the kernels must be crushed twice. By this method a ton of palm kernels will yield about 1,000 lb. of oil, or 43–45 per cent. By the use of a solvent nearly all the oil can be extracted, or any particular proportion required; but the whole of the oil can only be removed at the expense of the residual feeding-stuff, which as a result is less valuable. For this reason palm-kernel meal manufacturers usually leave a certain amount of the oil in the meal.

In West Africa small quantities of palm-kernel oil are prepared by rough methods by the natives for their own use for cooking purposes, and attempts have been recently made to start the manufacture of the oil from the kernel on a large scale under European supervision. A certain amount of palm-kernel oil has long been expressed in Liverpool or its neighbourhood, but nearly all the palm-kernel oil of commerce was, until the outbreak of the war (August 1914), expressed in Germany from kernels exported chiefly from British West Africa. Germany was in fact the creator of this modern industry, of which Harburg (close to Hamburg) was the centre.

Uses of Palm-Kernel Oil

Palm-kernel oil, which at European temperatures is a nearly white or pale yellow solid fat with a pleasant nutty taste, is used like

coconut oil (which in appearance and properties it much resembles) for the manufacture of soap and candles, and in increasing amount for the preparation of various edible fats, *e.g.* margarine, cooking fats, vegetable "butters" and chocolate fats. More than 35,000 tons of palm-kernel oil are stated to be used annually in Northern Europe in the manufacture of margarine. Its consistency can be varied according to the particular purpose for which it is required, as it admits of separation, under suitable treatment, into a liquid portion (olein) and a hard white fat (palm-kernel stearin).

The average price of the kernels in Hamburg, just before the outbreak of the war, ranged from £18 to £19 per ton; in Liverpool it was between £17 and £19 per ton. The price in Liverpool is from £13 to £14 per ton, according to quality. The price of the oil expressed in Liverpool is at present about £38 per ton.

PALM-KERNEL CAKE AND MEAL

The second product obtained from the palm kernel is palm-kernel cake or meal, which, as explained above, is composed of the residue of the palm kernel after the oil has been expressed or extracted. The cake or meal has no pronounced flavour, and is a valuable feeding-stuff for live stock.

In Germany it is highly valued as a food for milch cows, and also as a food for young pigs. Palm-kernel cake is also a popular feeding-stuff

in Holland, Denmark and Scandinavia, but in the United Kingdom it is still comparatively unknown.

It is most important that the merits of palm-kernel cake should be made known in this country, for without an adequate market for this feeding cake the utilisation in this country of palm kernels will be rendered less easy. The success which may attend the establishment of a palm-kernel crushing industry in Great Britain will in fact chiefly depend on the extent to which the feeding cake can be disposed of.

In order to determine the value of palm-kernel cake as a food for live stock in comparison with other foods, a number of experiments have now been made in this country. Trials were arranged for at a number of agricultural colleges in Great Britain by Sir Owen Philipps, Chairman of the West African Section of the London Chamber of Commerce. The results of the more important experiments at present available may be given here.

In a trial conducted at the North of Scotland College of Agriculture, a full report on which is promised shortly, the cake was compared with linseed and decorticated cotton-seed cakes as a food for fattening cattle. Three lots of animals were fed and otherwise treated alike, except that one lot received palm-kernel cake, another linseed cake and the third cotton cake. There was very little difference, on the average, between the three lots. They thrived equally well and made almost

equal increases in weight. The results therefore were quite favourable to palm-kernel cake.

An experiment in the winter feeding of cattle was undertaken at the Edinburgh and East of Scotland College of Agriculture to test palm-kernel cake, dried distillery grains and a mixture of chaffed hay and Bombay cotton cake against Bombay cotton cake. Thirty-two two-year-old bullocks were fed over a period of four months on a basal ration of 100 lb. swedes, $3\frac{1}{2}$ lb. medium wheat bran, and 7 lb. oat straw. One lot of eight animals received in addition an average of $4\frac{1}{2}$ lb. Bombay cotton cake per head per day, another lot an average of $4\frac{1}{8}$ lb. palm-kernel cake, a third lot 2 lb. Bombay cotton cake and $5\frac{1}{2}$ lb. chaffed hay, and a fourth lot $4\frac{1}{8}$ lb. dried distillery grains. The total live weight increase in the four lots was 1,580, 1,827, 1,435 and 1,811 lb. respectively; the outlay per cwt. of live weight increase, based on the average winter price for a few years previous to the war, and making allowance for the manurial values of the cakes, was 43s. 9d., 39s. 5d., 51s. 11d., and 39s. respectively. The results indicated that palm-kernel cake is a cheaper feeding stuff than first-class Bombay cotton cake, and is practically equal in value to the best class of dried distillery grains. In the report on this trial it is pointed out that cattle do not eat the palm-kernel cake "when it is first put before them, but in a few days they take it quite readily, and there appears to be no practical difficulty in feeding it to fattening bullocks when they are accustomed to it

from the beginning of the fattening period." The butchers' reports indicated that palm-kernel cake had no unfavourable effect on the quality of the beef, which, as a matter of fact, was reported be very satisfactory.

At the Norfolk Agricultural Station, ten bullocks were fed on a ration consisting of 90 lb. swedes, 7 lb. hay and straw chaff, 3 lb. of cotton cake (rising to $3\frac{1}{2}$ lb.) and 3 lb. of linseed cake (rising to $3\frac{1}{2}$ lb.). Another lot of ten bullocks of approximately equal total weight to the first lot were fed on the same ration except that the linseed cake was replaced by an equal weight of palm-kernel cake. At the end of eight weeks the animals receiving linseed cake showed a total gain in weight of 1,240 lb. while those receiving palm-kernel cake had gained 1,230 lb. As the difference between the two lots was considerably smaller than the probable error of the experiment, the results indicate that the two cakes have approximately the same feeding values.

At the Agricultural College, Uckfield, Sussex, also, favourable results were obtained. It was found that palm-kernel cake was equal to Bombay cotton cake as a milk producer and more valuable for beef production.

In an experiment carried out by Dr. Charles Douglas, Chairman of the Highland and Agricultural Society of Scotland, some young cattle, which were wintering out with hay feeding, were given 2 lb. of palm-kernel cake per day. These cattle wintered very much better than others

which had hay only, and Dr. Douglas states that the superiority in their condition was such as to show that palm-kernel cake is a very valuable food for field cattle, and as a result of his experience he strongly recommends it for this purpose. He adds that these cattle ate the cake greedily, but he was not successful in getting dairy cows to take to it.

At the Harper Adams Agricultural College, Shropshire, the cake was compared with decorticated cotton-seed meal as a food for milch cows. Two cows were given 3 lb. of palm-kernel cake, 4 lb. of dairy meal and 2 lb. of linseed cake per head per day, and another two were fed on a similar ration in which the palm-kernel cake was replaced by 2 lb. of decorticated cotton-seed meal. After three weeks the cows were changed over, and at the end of six weeks the total yield of milk obtained from animals fed with palm-kernel cake amounted to 3,412 lb., and from those fed with cotton-seed meal to 3,471 lb. After the first day or two the cows took the palm-kernel cake readily. It had no appreciable effect on the colour, taste or smell of the milk; the butter produced was of quite satisfactory texture, there was a slight tendency to paleness, but it was of good flavour.

An experiment comparing the value of palm-kernel cake with decorticated cotton-seed cake as a food for milch cows was also undertaken at the Lancashire County Council Farm at Hutton. No difficulty was experienced in getting the cows to eat $7\frac{1}{2}$ lb. of the cake per day, provided that it was

introduced gradually, and this comparatively large amount had no undesirable effects on the butter produced.

At the Armstrong College, Newcastle-on-Tyne, palm-kernel cake was compared with Bombay cotton cake as a food for milch cows. The basal ration consisted of 56 lb. swedes, 12 lb. meadow hay, 6 lb. oat straw, 2 lb. malt coombs, 3 lb. soy bean cake, and $\frac{1}{2}$ lb. oat-straw chaff, to which was added 6 lb. of either palm-kernel cake or cotton cake. Although the animals receiving palm-kernel cake did not increase in weight in any undue proportion compared with those receiving the cotton cake, yet in a short time the former had looser skins with a glossier look, and a better "bloom." An important result of this trial was to show substantial evidence that palm-kernel cake gives a higher percentage of fat in the milk. There was no evidence to show, however, that the total weight of butter fat produced per day in the milk had been increased. The conclusion is reached that palm-kernel cake is a very valuable addition to dairy cattle foods.

A similar trial was conducted at the Garforth Experiment Station of the Leeds University, where palm-kernel cake was compared with Egyptian cotton cake as a food for milch cows. Up to 4 lb. of cake per head per day were fed in each case. In this experiment also there was an increase in the yield of fat when palm-kernel cake was fed, but it was only slight. The results also indicated a gain in the milk yield in favour

of palm-kernel cake of about $5\frac{1}{2}$ lb. per day on a total yield for four cows of about 140 lb. per day.

At the Hampshire Farm Institute, Sparsholt, eighteen dairy cows, which had been receiving a mixture of soy bean and decorticated cotton cakes, were given palm-kernel cake, in gradually increasing amounts from 1 lb. to 4 lb. per day. The milk and butter were quite normal. The results showed that whilst palm kernel cake is a safe and suitable food for dairy cows, it should be given from the commencement of the winter feeding, before the cows have become accustomed to other concentrated foods.

No systematic experiments with palm-kernel cake have so far been carried out at the University College of North Wales, Bangor, but a good deal of the cake has been fed to dairy cows and fattening sheep, and Professor R. G. White states that from careful observation of the animals he has no hesitation in recommending the use of the food, if it can be obtained at a reasonable price compared with other cakes, such as cotton cake. It was found that although the cows and sheep would not take to the cake at first, with the exception of a few animals they soon became accustomed to it, and took it if mixed with a small quantity of other food.

A feeding trial comparing palm-kernel cake with linseed cake as a feeding stuff for sheep has been conducted at the South-Eastern Agricultural College, Wye. Two lots of sheep were fed alter-

nately on rations containing either linseed cake or palm-kernel cake. The results were inconclusive, as excessively wet weather prevailed during the period of the experiment. No difficulty was experienced in getting the sheep to eat the palm-kernel cake. They took to it immediately and seemed to relish it, and no bad effects whatever were observed from its use. The average increase in live weight per sheep per day was greatest during the time when the linseed cake was fed, but Mr. W. A. Stewart in reporting the results of this experiment states that he considers palm-kernel cake is a better feeding-stuff than the figures obtained show, and that a further trial is necessary before its precise value can be finally determined.

On the whole the results of these feeding trials are quite satisfactory and indicate that British farmers need have no hesitation in employing palm-kernel cake as a feeding stuff. Further testimony to the value of the cake is afforded by Dr. J. A. Voelcker, Consulting Chemist to the Royal Agricultural Society of England, in his Annual Report for 1914 (*Journ. Roy. Agric. Soc.*, 1914, 75, 271). He states that there is every reason why palm-kernel cake should be extensively and advantageously used in this country, inasmuch as it is an excellent food, more especially for dairy stock. He mentions that one inconvenience attaching to the cake is that it does not keep as well as linseed and cotton cakes, and that there is a tendency for it to turn rancid. It should be

pointed out, however, that in the experiment conducted at the Lancashire County Council Farm at Hutton no difficulty was experienced in keeping the cake, and that there is now abundant evidence that well prepared cake can be kept without change.

Enquiries instituted by the Board of Agriculture have shown that the cake is already being used to a certain extent by farmers in this country, and although opinions as to its merits vary somewhat, on the whole they are quite favourable. A fair amount is being used in Northumberland, Wales, and elsewhere, while it is expected that it will be extensively purchased in Staffordshire during the coming winter. In Herefordshire it is stated to be finding favour for pig-feeding, the flesh of pigs fed on the cake being very firm.

As is usually the case with new feeding stuffs, some difficulty may be encountered in getting certain animals to take to palm-kernel cake at first. In most of the trials referred to above, the animals, both cows and sheep, took to it readily, and where any difficulty is encountered it is probably due to some idiosyncrasy in the animal. This could no doubt be got over by introducing the cake gradually, and mixed with other rations, or by adding a moderate quantity of flavouring material. In the case of sheep it has been suggested that the cake should be damped overnight.

No systematic experiments with pigs have yet been made here, but good results have been obtained in Germany.

Commercial Feeding Values and Prices

The following table gives the composition, the ante-war prices, and the price in March 1915, in the United Kingdom of palm-kernel cake, linseed cake and undecorticated cotton-seed cake, the two latter being the chief feeding cakes used in the United Kingdom. The feeding values of the different constituents have already been considered in the section on coconut cake (p. 22).

Name of Cake.	Moisture.	Crude proteins.	Fat.	Carbo-hydrates (by difference).	Crude fibre.	Ash.	Value July 1914 per ton.	Value March 1915 per ton.
	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.		
Palm-kernel cake	12.0	18.5	5.5	50.0	10.0	4.0	—	Liverpool made, £5 15s. to £6
Linseed cake (expressed)	10.0	33.5	8.6	31.7	8.7	6.5	London made, £7 17s. 6d. to £8	British, £11 15s. to £12 15s.
Cotton-seed cake (undecorticated, expressed)	10.5	24.5	6.5	26.3	25.0	7.2	London made, £4 17s. 6d. to £5	British, £6 17s. 6d. to £7 5s.

The cost per food unit of palm-kernel cake as compared with linseed and cotton-seed cakes, calculated by the method already described under coconut cake (pp. 24, 27) is shown in the following table :

	Current value per ton.	Estimated value of manure arising from the consumption of 1 ton of feeding stuff.	Cost per food unit per ton, calculated on the net value, i.e. the current value less the estimated value of the manure.
Palm-kernel cake, English made	£5 15s. to £6 (Liverpool, April 1915)	£1 2s. 11d.	1s. 4½d. to 1s. 5½d.
Linseed cake, English made	£11 15s. to £12 15s. (Liverpool, March 1915)	£2 4s. 4d.	2s. 6½d. to 2s. 9½d.
Decorticated cotton-seed cake, English made	£11 to £11 10s. (Liverpool, March 1915)	£3 4s. 9d.	2s. 0½d. to 2s. 1¼d.
Undecorticated cotton-seed cake, English made	£6 17s. 6d. to £7 5s. (Liverpool, March 1915)	£1 15s. 4d.	2s. 2½d. to 2s. 4½d.

The "starch equivalent" of palm-kernel, linseed and cotton-seed cakes and the "milk unit" (see p. 70) of palm-kernel and decorticated cotton-seed cakes are as follows:

	"Starch equivalent."	"Milk unit."
Palm-kernel cake . . .	78·8	72·4
Linseed cake . . .	71·8	
Decorticated cotton-seed cake . . .	72·3	87·2
Undecorticated cotton-seed cake . . .	39·2	

British and German Palm-kernel Cakes

The tables on pp. 44, 45 show the food value of British and German palm-kernel cakes and

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meals respectively. It is satisfactory that in both cases the British-made article is superior in quality to the German product.

CRUDE NUTRIENTS

	Palm-kernel cake (expressed).				Palm-kernel meal (extracted).	
	English.			German.	English.	German.
	1.	2.	3.	4.	5.	6.
	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.
Moisture . . .	12·0	12·0	10·85	9·7	15·0	10·9
Crude proteins . .	16·75	18·5	16·12	17·7	19·0	18·7
Fat . . .	7·07	5·5	6·17	8·6	2·0	1·6
Carbohydrates . .	46·83	50·0	48·51	36·2	51·0	39·1
Crude fibre . . .	13·55	10·0	14·80	23·8	9·0	25·4
Ash . . .	3·8	4·0	3·55	4·0	4·0	4·3
Food units . . .	106	110	104	102	104	90

1. Factory analysis (1914).

2. Average of factory analyses taken over a period of three months (1914).

3. Lloyd (*Field*, November 14, 1914, p. 837), (1914).

4. Kellner (*Scientific Feeding of Animals*, p. 377), (1905).

5. Average of factory analyses taken over a period of three months (1914).

6. Kellner (*loc. cit.*).

The lower proportion of crude (indigestible) fibre in the British-made cake and meal is probably due to the careful removal in the British mills of all fragments of palm-nut shells. The result, of course, is a corresponding increase in feeding value.

Samples of British-made palm-kernel cake and meal may be seen in the Reference Collections of

Standard Commercial Products in the Public Exhibition Galleries of the Imperial Institute.

DIGESTIBLE NUTRIENTS¹

	Palm-kernel cake (expressed).				Palm-kernel meal (extracted).	
	English.			German.	English.	German.
	1.	2.	3.	4.	5.	6.
	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.
Crude proteins .	12·56	13·88	12·09	13·28	18·05	17·77
Fat . . .	6·93	5·39	6·05	8·43	1·90	1·52
Carbohydrates .	36·06	38·50	37·35	27·87	47·94	36·75
Crude fibre . .	5·28	3·90	5·77	9·28	7·38	20·83
Food units . .	67	67	65	63	75	71

¹ Calculated from the analyses shown in the preceding table, using the digestibility coefficients of Kellner (*loc. cit.*, p. 388).

GROUND NUTS

THE ground nut (*Arachis hypogaea*, Linn.), so called because the nut matures underground, but better known in this country as the “monkey-nut,” and in the United States as the “peanut,” occupies an important place among tropical products. The nut is highly nutritious and contains a large proportion of oil which is used for edible purposes, and also for the manufacture of soap. The cake left after expression of the oil forms a valuable feeding for live stock.

THE TRADE IN GROUND NUTS

The chief countries from which ground nuts are exported are, India, Gambia, Nigeria, Senegal, and China. Of these five countries, three—India, Gambia and Nigeria—are British, and the yearly output from these three countries alone exceeds 7,000,000 cwts., and is worth nearly £4,000,000. Attention is also being given to this crop in other parts of the Empire, notably in Uganda, Nyasaland, Sudan, Rhodesia, Natal, and the West

Indies. The chief reason for this is that the ground nut, like other leguminous plants, is able to derive nitrogen from the air and to add it to the soil on which it is grown, and the plant therefore fills a useful place in the rotation of tropical crops. Other leguminous plants, such as beans, might be selected for this particular purpose, but the great majority of beans suitable for cultivation by natives in the Tropics fetch low prices, and will not bear the cost of transport to Europe. There has been, therefore, in recent years, a slowly but steadily increasing production of ground nuts in tropical parts of the British Empire. This, unfortunately, has not been accompanied by any corresponding effort to widen the field of utilisation at home.

The chief ground-nut importing countries before the war, in order of importance, were France, Germany and Holland; the most important manufacturing centres have hitherto been Marseilles, Bordeaux, Dunkirk, Delft, Hamburg, Trieste, and Valencia. The present annual supply of ground nuts to all European mills is estimated at about 600,000 tons.

In the following tables are shown the quantities shipped from the most important exporting countries, and the imports to France and Germany, for the latest years for which statistics are available. The imports of ground nuts into the United Kingdom are not separately shown in the trade returns for this country, but they are known to be small.

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EXPORTS FROM THE CHIEF GROUND-NUT PRODUCING COUNTRIES

Country.	Quantity. cwts.	Value. £
BRITISH TERRITORIES :		
India (1913-14) .	5,558,120	3,254,246
Gambia (1913) .	1,348,089	622,098
Nigeria (1913) .	385,760	174,716
FOREIGN TERRITORIES :		
<i>French Possessions :</i>		
Senegal (1912)	3,635,864	1,846,529
Upper Senegal and Niger (1912) .	114,736	41,978
<i>Dutch Possessions :</i>		
Java (1913) .	842,000	
<i>Portuguese Possessions :</i>		
Mozambique (1912)	71,811	32,571
Lourenço Marques (1912) . . .	28,840	17,155
<i>China</i> ¹ (1912) .	1,019,948	549,221

The distribution of the nuts from the more important exporting countries was as shown in the following tables :

Including re-exports.

India

The chief countries of destination for the exports from India in 1913-14 were as follows :

Country.	cwts.	£
France . . .	4,447,593	2,620,541
Belgium . . .	332,157	199,292
Austria-Hungary	214,114	111,729
Germany . . .	188,724	115,821
United Kingdom	9,603	5,564

It appears, then, that 80 per cent. of the total Indian export of ground nuts was shipped to France ; a considerable quantity has hitherto gone to Germany and Austria-Hungary, and an almost negligible quantity to the United Kingdom. Of the total export of ground nuts from India, nearly three-fourths come from Madras.

Gambia

The chief countries to which ground nuts were exported from this colony in 1913 were as follows :

Country.	cwts.	£
France . . .	848,414	385,662
Germany . . .	342,736	162,403
Holland . . .	88,800	39,967
United Kingdom	19,695	10,701

Nigeria

The chief countries of destination for the exports from Nigeria in 1913 were the following :

Country.	cwts.	£
Germany . .	188,460	93,668
United Kingdom	186,760	77,693
France . .	10,440	3,305

Senegal

The exports from this French colony to the more important countries of destination in 1912 were as follows. It will be noted that over 70 per cent. of the total export went to France.

Country.	cwts.	£
France . .	2,577,377	1,175,278
Holland . .	504,767	224,941
Germany . .	379,073	168,588
United Kingdom	2,063	931

China

The chief destination of ground nuts shipped from China in 1912 was France, to which country there were exported 403,968 cwts., valued at £230,935.

It is clear from the foregoing tables that the principal market for ground nuts is France. Germany has in recent years begun to take considerable quantities of the nuts, but so far her imports are small compared with those of France.

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This fact is further illustrated by the following tables showing details of the imports into these two countries :

FRANCE. IMPORTS (1913)

From	Uncorticated. cwts.	Decorticated. cwts.
<i>French Territories :</i>		
Senegal	3,420,901	—
Other French West African Possessions	57,560	—
French India	111,656	1,646,057
Other Colonies and Protectorates	403	844
<i>Other Territories :</i>		
Spain	14,637	—
Egypt	—	6,065
British West Africa .	779,513	—
Other countries on West Coast of Africa	80,847	—
British East Africa .	—	73,519
Other countries of Africa	—	63,959
British India	527,433	3,159,575
Dutch East Indies . .	122,019	37,277
China	60,598	282,879
Other foreign coun- tries	6,033	10,829
TOTAL	<u>5,183,523</u>	<u>5,287,205</u>

(value £3,487,542) (value £4,202,128)

GRAND TOTAL 10,470,728 cwts. (value £7,689,670)

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GERMANY. IMPORTS (1913)

From	cwts.
French West Africa . . .	609,245
British West Africa . . .	469,808
British India, etc. . . .	423,184
China	194,487
Portuguese West Africa . .	98,762
German East Africa . . .	63,595
Portuguese East Africa . .	13,622
Dutch East Indies, etc. . .	8,078
Other countries	49,417
TOTAL	1,930,178
(value £1,318,250)	

From both countries there are considerable exports of ground-nut oil, and from France an important quantity of ground nuts is re-exported. These data are given in the following tables. A considerable amount of ground-nut cake is also exported from France (see p. 68).

EXPORTS FROM FRANCE (1913)

(1) *Ground Nuts*

To	Uncorticated.	Decorticated.	Total.
	cwts.	cwts.	cwts.
Spain	92,483	503,732	596,215
Russia	116,428	2,576	119,004
Argentina	8,182	54,746	62,928
Algeria	51,396	2,092	53,488
United Kingdom	29,451	23,349	52,800
Italy	29,394	12,201	41,595
Turkey	25,114	4,648	29,762
Other countries	112,411	39,515	151,926
TOTAL	464,859	642,859	1,107,718
Value	£320,583	£512,664	£833,247

(2) Ground-nut Oil

To	cwts.
Algeria	165,239
Italy	60,998
Switzerland	50,588
United States	48,647
United Kingdom	39,450
Holland	34,768
Other countries	90,121
TOTAL	<u>489,811</u>
Value	£904,574

Taking the available percentage of oil in decorticated nuts as 43 and that in undecorticated nuts as 32, the oil exported from France corresponds to about 1,138,630 cwts. of decorticated, or 1,530,659 cwts. of undecorticated nuts.

The exports of nuts and oil are thus together equivalent to about 2,500,000 cwts. of nuts, or over 20 per cent. of the total import.

EXPORTS FROM HAMBURG (1913)

No separate figures are published for exports of ground nuts and ground-nut oil from Germany; the following tables are therefore given, showing the exports from Hamburg to foreign countries in 1913 :

(1) *Ground Nuts*

To	cwts.
Holland .	91,966
Belgium .	32,546
Argentina .	4,733
United Kingdom	2,887
Other countries	7,651
TOTAL .	139,783
Value	£112,914

(2) *Ground-nut Oil*

To	cwts.
Denmark	18,026
United States	10,327
United Kingdom	9,273
Norway	8,810
Other countries	2,129
TOTAL	48,565
Value	£102,764

The total exports from France and from Hamburg to foreign countries for the years 1911, 1912 and 1913 were :

France

	1911.	1912.	1913.
	cwts.	cwts.	cwts.
Ground nuts	1,262,231	744,701	1,107,718
Ground-nut oil	374,413	379,573	489,811

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Hamburg

	1911.	1912.	1913.
	cwts.	cwts.	cwts.
Ground nuts . . .	112,944	66,241	139,783
Ground-nut oil . . .	7,251	22,201	48,565

The figures previously given illustrate the dependence of the countries exporting ground nuts on the French and German markets. The war has had the effect of stopping trade with Germany, and the industry at Marseilles is at present considerably curtailed owing to the fact that the export of feeding cakes, including ground-nut cake, most of which has hitherto been exported, has been severely restricted by Government. The result is that there are at present in Marseilles large quantities of ground nuts and cake already in stock for which there is no ready market.

The diminution in the demand for ground nuts since the outbreak of war affects chiefly India and the Gambia.

It is understood that considerable quantities of Indian ground nuts have lately been shipped to Marseilles, but the demand there is still far below the normal, and must remain so until markets can be found for the cake.

Recently some quantity of Indian ground nuts has also been imported into Hull for the production of oil, but the amount so far disposed of in this way is very small in comparison with the supply available in India.

The question is under consideration in India of establishing crushing mills in that country, as it is believed that in the present disorganised state of commerce the oil would be easier to market than the nuts. The desirability of such a step is best judged by the authorities in India who have local knowledge of market conditions, but in any case a change of such a kind can only be effected slowly, and will do very little to satisfy the immediate exigencies of the situation. Ground-nut oil is admitted into the United Kingdom without duty, but it is to be noted, in connection with the economic side of the question, that in several countries there are import duties on the oil, while the nuts are almost everywhere admitted free. The disposal of the cake produced in India would also have to be arranged for.

In India about a million acres are under ground nuts; the annual production is, in round figures, 550,000 tons, and of this quantity only about half is exported, the remainder being used in the country. It seems likely that this internal consumption will increase, owing to the increased consumption of vegetable oils for food. There is no prejudice among the Hindus against the use of artificial "butters," provided that they are entirely vegetable, and it is not unlikely that sooner or later an important margarine industry will develop in that country and will lead to an enhanced use of ground nuts, the oil of which can be used in the manufacture of margarine. Such a state of affairs is, however, for the present, somewhat remote,

and India will necessarily be dependent, for some years to come, upon other markets for the disposal of its crops of ground nuts.

In these circumstances it is very desirable that British manufacturers and traders should take prompt action and interest themselves in ground nuts, with a view to establishing a market in the United Kingdom, and to the establishment of crushing centres in this country for dealing with Indian and other British-grown ground nuts.

The ground nuts imported into the United Kingdom in normal times are mainly used as such for edible purposes, but the market in this country is at present not large. It is, however, to be hoped that British consumers will not be slow to recognise their merits, and that the consumption of the nuts will be largely extended. At the present time, when foodstuffs of all kinds are rising in price, it is desirable that attention should be directed to new sources of supply, and in this connection ground nuts, which can be prepared in a great variety of pleasant forms, and are moreover highly nutritious, are important.

Meanwhile, as the figures quoted show, there are some possibilities for trade with neutral European countries. Nor is it only in the European markets that openings are to be found. In the United States, for instance, there is a large consumption of ground nuts, which are used almost exclusively for edible purposes, or for expressing oil. The nut is grown in the United States, but not in sufficient quantity to meet the demand. In the

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year 1912-13 the imports from other countries were as follows :

	cwts.	£
Uncorticated nuts	109,657	97,998
Decorticated nuts .	60,727	65,083
TOTAL . . .	<u>170,384</u>	<u>163,081</u>

This quantity was chiefly obtained from Spain and Japan, but there is no obvious reason why nuts grown in India and British West Africa should not supply this market. Indian ground nuts are often decorticated before export, and as a rule deteriorate during the sea voyage. The United States import is largely in uncorticated nuts, as the best qualities of edible oil are obtained from freshly-shelled nuts. In the year 1912-13 the United States imported 1,195,683 gallons, or say 98,000 cwts. (£170,992) of ground-nut oil, mostly from France, Germany, and Holland. The United States exports of ground nuts for the year in question amounted to 65,191 cwts. (£76,253), of which 47,926 cwts. (£57,766) went to Canada. The total imports into Canada from all sources are not available.

The question of trade with neutral countries is, however, at present only of prospective interest, as the export of oils and feeding cakes from the United Kingdom is prohibited during the present crisis except under special licence, and similar measures have been adopted by the other allied belligerent Powers.

The average price for ground nuts in the Liverpool market during 1914 was about £14 to £17 per ton, undecorticated; and £15 10s. to £17 per ton, decorticated.

The average price at Marseilles, during 1914 at the beginning of the war, was £12 5s. to £15 10s. per ton undecorticated, and £13 to £16 5s. per ton decorticated—better prices, up to about £1 higher than these, being paid for especially good qualities.

The reason for the higher prices ruling in the Liverpool market is that ground nuts are used in this country mainly for edible purposes, and the chief demand is therefore for better qualities than are for the most part sent to Marseilles.

The price of ground nuts has been continually increasing since 1904; thus the following were the Marseilles quotations for undecorticated Gambia nuts in that year, and in 1914 (January to July) respectively:

Year.	Price per ton.					
	Highest.			Lowest.		
	£	s.	d.	£	s.	d.
1904 . .	9	12	6	7	10	0
1914 . .	13	5	0	11	5	0

The oil was generally quoted at Marseilles during 1914 (January to July) at £28 10s. to £38 10s. per ton, the higher prices (from about £33 5s. upwards) being paid for edible qualities.

Marseilles quotations for the cake averaged £6 10s. to £7 per ton in June and July 1914.

UTILISATION OF GROUND NUTS

Articles have appeared in recent years in the *Bulletin of the Imperial Institute* (1910, 8, 153; 1913, 11, 547) on the subject of ground nuts. These have dealt mainly with their cultivation and with the manufacture of oil, cake and other products. In the remaining part of the present article it is proposed to consider more fully the consumption of the nuts and their products, and the prospects of increasing the demand for these.

Ground nuts, as such, are largely used as an article of food in various parts of the world, but their chief industrial interest lies in their use as sources of oil and feeding cake. These two products will therefore be considered first.

GROUND-NUT OIL

The nut consists of about 70-75 per cent. kernel and 25-30 per cent. shell. The percentage of oil in the kernel varies. It appears to depend more upon richness of the soil, and other conditions under which the plant is grown, than upon the particular variety of the plant grown. The average quantity is 48 per cent. Of this about 30-35 per cent. is obtained by cold-pressing, and a further 8-12 per cent. by hot-pressing—that is, about 43 per cent. The hot-pressed oil is of somewhat inferior quality to that expressed in the cold. A very good quality of oil can also be ob-

tained by extracting the ground kernels with solvents (carbon disulphide, etc.). The crude oil is also susceptible of purification, to form a refined oil of excellent quality. The oil is limpid, of a light colour, faint nutty odour and bland taste.

The best grades are made at Marseilles, Bordeaux, and Delft, partly from nuts received in their shells from West Africa, and partly from decorticated nuts from India.

Coromandel shelled nuts are generally received at Marseilles in a bad condition. It is the custom of the Coromandel natives, in shelling the nuts, to wet them, and they are shipped while still moist. In this condition they undergo during the voyage much more "heating," with resulting deterioration in the oil, than they would if kept dry. This evil ought to be remedied, but the Indian merchants have not hitherto succeeded in altering native methods to any large extent. It is stated that water is often added to the nuts in the sacks in order to increase their weight. The oil obtained from such nuts is chiefly employed for soap making, but an increasing quantity of crude oil is now refined at Marseilles for edible use.

The better qualities of the oil, Rufisque (Senegal), Gambia, etc., are used extensively for edible purposes. The oil has excellent qualities as a salad oil, and is often used as a substitute for olive oil, or for blending with olive oil of harsh taste. An equally important use of ground-nut oil for edible purposes is in the manufacture of margarine, and the following table shows approximately the

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quantities of this and other oils at present estimated to be consumed annually in the margarine industry in Northern Europe (United Kingdom, Germany, Holland, Denmark, Norway, and Sweden). The following approximate figures are given by Mr. E. W. Thompson (*U.S.A. Dept. of Commerce, Special Agents Series, No. 89, 1914, Cotton Seed Products and their competitors in Northern Europe ; Part II, Edible Oils*).

	Tons.
Oils :	
Ground-nut oil	35,000
Cotton-seed oil : American . .	57,000
" " other	17,000
Sesame oil	32,000
Soy-bean oil	6,000
Rape oil	3,000
Fats :	
Coconut oil	169,000
Palm-kernel oil	35,000
Animal fats	143,500

The lowest grades of the oil are used mainly for soap making, and ground-nut oil is a characteristic constituent of white Marseilles soap. Ground-nut oil is non-drying, and can be used as a lubricant ; it also forms a very good medium for wool-oiling and for other industrial purposes. It is occasionally used as an illuminant, and it is also employed as a curry oil and for preserving sardines.

It is official in the British Pharmacopœia, for use in India and in the Eastern, African and

Australasian divisions of the Empire, instead of olive oil in making sundry medicinal preparations in which that oil is directed to be used.

As has been mentioned already, an important use of ground-nut oil is in the manufacture of margarine.

Margarine consists essentially of a mixture of fats and oils blended with water, milk and salt. The fats may be either of animal or vegetable origin, whilst the oils are entirely vegetable. Taking the whole of the margarine manufactured in Europe, this is estimated to contain, on an average, 25 per cent. of animal fat, 35 per cent. of vegetable fat (coconut and palm-kernel oils), 26 per cent. of vegetable oil, and 14 per cent. of water, milk and salt.

There is, however, an increasing preference for the use of vegetable fats in place of animal fats in the preparation of margarine, due largely to the belief that vegetable fats are more wholesome. Vegetable fats are on the whole harder than animal fats, and the increase in their use will therefore allow more vegetable oils to be used. This increase indicates a good opening for extending the use of ground-nut oil.

Artificially hardened fats are already being used in the margarine industry, and the increasing use of the various hydrogenation processes, whereby certain oils, notably linseed and fish oils, can be hardened to any desired degree, has also to be taken into account. There is not, perhaps, much immediate prospect of ground-nut oil itself

being extensively hardened, since at present the whole supply in Europe is readily taken up in its natural state, and commands a good price. The increasing use of hardened fats in the margarine industry will, however, call for a more extensive use of the best class of oils for blending with them, and of these ground-nut oil is one of the most important.

The position is summarised by Mr. E. W. Thompson in the pamphlet referred to above (No. 89), which is printed in the interests of the American cotton-seed oil trade in Europe. After estimating the total annual consumption of oils for margarine manufacture in the United Kingdom, Germany, Holland, Denmark, Norway and Sweden to be 150,000 metric tons, the author says :

“Competition with peanut oil.— . . For margarine, cottonseed oil has no formidable competitor except peanut [ground-nut] oil. Assuming the maximum consumption of sesame at 32,000 tons, soya at 6,000 tons, and colza [rape] at 3,000 tons, total 41,000, there remain 109,000 tons (599,500 barrels) of the 150,000 tons of soft oil to be contested between peanut and cotton seed. As already shown, only some 60,000 tons of peanut oil are actually competing for this trade. So, if the American exporters were to give up without a struggle, and let the whole 60,000 tons of peanut oil in, the trade would be compelled to have, even on its present basis, 49,000 tons (269,500 barrels) of cotton-seed oil.”

In other words, if ground-nut oil were on the

market in sufficient quantities, it would readily compete favourably with the best American edible cotton-seed oil, but at present the quantity offered is so small, that it is hardly taken into account as affecting American cotton-seed interests.

Other competitors of ground-nut oil for edible purposes, which may be mentioned in passing, are sesame and rape oils.

The former, referred to in a succeeding monograph, is sold at a high price, and has a good reputation as a salad oil. It is, however, only available in limited quantities. It is in some countries legally required to be a component of margarine, as it can be recognised by a simple chemical test (Baudouin reaction), and therefore serves as a ready method of distinguishing margarine from butter. The total import into Europe is not much more than twice the amount thus legally required in the manufacture of margarine, and it need not at present be considered as a serious competitor with ground-nut oil.

Rape oil is used for illuminating and lubricating, and some varieties of the seed produce a good edible oil, but as commonly imported into Europe the seeds are mixed, and the oil obtained from them cannot be marketed for edible purposes without previous refining. Ground-nut oil is now being made in several mills in France of a quality that commands a good price as a salad oil, without undergoing any refining process as ordinarily understood. This oil is prepared by cold-pressing from the best nuts.

Soya or soy-bean oil may also be regarded as a competitor. It is used extensively in the soap industry, and is to some extent refined and sent to the Mediterranean for blending with salad oils. But it is losing its popularity, especially rapidly in the United Kingdom, as the following figures (*loc. cit.*) show :

APPROXIMATE QUANTITIES OF SOY BEANS IMPORTED
INTO THE UNITED KINGDOM

Year.	Tons.
1910	413,300
1911	219,300
1912	188,700
1913	76,500

This decrease is probably largely due to the difficulty in disposing of the cake, soy-bean cake not being favourably regarded in the United Kingdom.

In Germany and Denmark, where the cake is in demand, there is an increase in the annual quantities of soy beans crushed.

Hitherto a large proportion of the margarine consumed in the United Kingdom has been made from coconut and palm-kernel oils expressed in Germany, and refined in Holland or the United Kingdom. There is a large annual import of manufactured margarine into this country (1,518,297 cwts., valued at £3,917,701 in 1913). According to the American pamphlet referred to above, about three-fifths of the cotton-seed oil

used in the margarine industry in the United Kingdom is of American origin.

GROUND-NUT CAKE

The cake or meal left after expression or extraction of the oil from ground nuts is in the very front rank as a cattle food. It contains a higher percentage of protein, and of protein and oil combined, than any other oil cake, and is, moreover, easily digested.

It is in great demand in Germany, and commands a high price. It is also regarded as a valuable cattle food in other Continental countries, notably in Sweden. Inferior cake is used in considerable quantities as a manure, especially in connection with intensive market-gardening in France. In the United Kingdom ground-nut cake has not yet received much attention, owing to the general use of cotton-seed and linseed cakes, large quantities of which are made here and imported. The British farmer does not take readily to new feeding-stuffs, but it should not be difficult to induce him to appreciate the exceptional value of this material, which is already so highly esteemed on the Continent.

The best quality of ground-nut cake is that known as Rufisque, and made in France, Germany, or Holland, from nuts imported in the shell from the West Coast of Africa, chiefly from Senegal. The nuts are shelled before being pressed, and yield a nearly white cake resembling coconut

cake in appearance. The colour of the cake depends on the extent to which the inner red pellicle is removed from the kernel before pressing. The best and whitest Rufisque cake is made at Bordeaux, where the pellicle is practically entirely removed. This cake may contain as much as 62 per cent. of protein and oil, and is generally more highly priced than any other oil-cake or meal made. A cake of good quality has also been made in Germany by crushing nuts shelled by machinery in the Bombay district.

Out of a total of 281,000 tons of oil-seed cakes produced in Marseilles in 1913, 140,000 tons consisted of decorticated ground-nut cake. Large quantities of the latter were exported, principally to Germany and Sweden. The official returns do not distinguish between ground-nut cake and other oil-cakes, but an idea of the extent of the trade with those countries may be ascertained from the following figures showing the total exports of oil-cake from Marseilles in 1912 and 1913:

Country of destination.	1912. cwts.	1913. cwts.
Germany . . .	1,775,834	1,116,523
Sweden . . .	510,108	1,028,166
Other countries	310,587	469,853
TOTAL . . .	<u>2,596,529</u>	<u>2,614,042</u>

The import of oil-seed cakes of various kinds to the United Kingdom in 1913 was 406,760 tons, of value £2,539,892; it is obvious, therefore, that

there is no difficulty in disposing of good feeding cakes in this country.

The composition of ground-nut cake is compared with those of other feeding cakes in common use in the following table. The analyses are by Smetham (*Journ. Roy. Lancashire Agric. Soc.*, 1914).

	Moisture.	Proteins.	Fat.	Digestible carbo- hydrates.	Crude fibre.	Ash.	Nutrient ratio.	Food units.
	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.		
Ground-nut cake, decorticated, Rangoon	8.25	48.00	5.53	28.35	1.67	8.20	1:0.86	162
Ground-nut cake, decorticated, American	6.10	40.00	16.90	27.90	4.70	4.40	1:1.67	170
Ground-nut cake, undecorticated, Burma	10.10	28.50	9.33	25.20	22.47	4.40	1:1.64	120
Linseed cake, Eng- lish made, aver- age (expressed)	11.16	29.50	9.50	35.54	9.10	5.20	1:1.94	133
Linseed meal (ex- tracted)	13.15	34.75	3.03	34.67	8.75	5.65	1:1.20	129
Cotton-seed meal, decorticated, At- lantic Ports (ex- pressed)	7.40	42.37	10.16	25.86	7.06	7.15	1:1.16	157
Cotton-seed cake, undecorticated, English made (expressed)	13.75	24.62	6.56	29.28	21.19	4.60	1:1.67	107

The "nutrient ratio" is the ratio between the percentage of crude proteins and the sum of the percentages of starch and oil, the latter being first multiplied by 2.3 to convert it into its starch equivalent.

The "food units" are obtained by adding the percentage of carbohydrates to two-and-a-half times the combined percentages of proteins and oil.

A feature of feeding-stuffs to which importance is attached by some authorities is the "starch equivalent," which denotes the weight of starch, equivalent for fattening purposes, to 100 lb. of the food. Its practical utility is doubtful. The following figures, quoted from Kellner, were obtained by actual feeding experiments.

Cake.	Starch equivalent
Ground-nut	75·7
„ „ (Rufisque)	77·5
Cotton-seed, decorticated	72·3
„ „ undecorticated	39·2
Rape, pressed	61·1
„ „ extracted	53·3
Linseed, pressed	71·8
„ „ extracted	64·8
Palm-kernel, pressed	78·8
„ „ „ extracted	66·1
Coconut	76·5

Another unit of some interest is Professor Hannson's "milk unit," which is adopted in Sweden. As the result of extensive experiments, he attaches a higher value to proteins for milk production than Kellner, whose valuations are based on feeding cattle for beef rather than for milk. His figures are as follows :

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Cake or food.	Milk units.
Ground-nut cake . . .	94.3
Cotton-seed cake (decorticated) .	87.2
Coconut cake . . .	87.5
Palm-kernel cake . . .	72.4
Dried potato . . .	72.6

Lastly, ground-nut cake is easily digestible, as the following figures from Kellner, based on experiments with ruminants, show :

Cake.	Percentage of digestibility.			
	Protein.	Fat.	Carbo- hydrates.	Total organic matter.
Ground-nut	90	90	84	83
Linseed	86	92	78	79
Cotton-seed, decorticated	86	94	67	76
„ undecorticated	77	93	52	55
Rapo	81	79	76	66
Coconut	78	97	83	80
Palm-kernel	75	98	77	70
„ „ (extracted)	95	95	94	91

Indirect Manurial Value of Ground-nut Cake

The manure produced by animals fed on ground-nut cake is exceptionally rich in constituents of value to the farmer. The following table of manurial values is given by Voelcker and Hall (*Journal of the Royal Agricultural Society*, 1913, 74, 114, revised from Lawes and Gilbert's Tables, 1897, and Voelcker and Hall's Tables, 1902).

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Cake.	Manurial constituents of cake, <i>per cent.</i>			Manurial value per on of cake.		
	Nitrogen.	Phosphoric acid.	Potash.			
Ground-nut	7.62	2.00	1.50	£	s.	d.
Cotton-seed, decorticated .	6.90	3.10	2.00	3	6	2
Cotton-seed (Egyptian), un- decorticated	3.54	2.00	2.00	1	17	1
Cotton-seed (Bombay), un- decorticated	3.10	2.50	1.61	1	13	8
Linseed	4.75	2.00	1.40	2	4	4
Soy-bean	6.85	1.30	2.20	3	0	10
Palm-kernel	2.50	1.20	0.50	1	2	11
Coconut	3.40	1.40	2.00	1	14	7
Rape	4.90	2.50	1.50	2	6	11

The calculation of manurial value is based on the assumption that 50 per cent. of the nitrogen and 75 per cent. of the phosphoric acid and potash in the fodder are contained in the manure. The nitrogen is valued at 15s., the phosphoric acid at 3s., and the potash at 4s. per unit. The nitrogen content of the fodder is taken as 16 per cent. of the protein content.

The manurial values given above are for cases where the manure is produced in the stable and subsequently applied to the land.

In the cases where the fodder is consumed on the land, it may be taken that as much as 70 per cent. of the nitrogen is returned to the land; this is largely because of the valuable nitrogenous constituents of the urine, which are to a considerable extent lost as ammonia in the making and storage of stable manure.

It has already been mentioned that ground-nut

cake is sometimes applied directly to the land as a manure, especially in intensive market gardening in France. Its value for this purpose, based on the analysis given in the preceding table, would be £6 6s. 4d. per ton.

Ground-nut Meal for Human Food

It seems possible that the residue left after the oil has been removed from kernels of good quality might find some use as a human food, in bread, biscuits and pastry. A "soya bean flour" has for some years been made by a well-known firm in Great Britain, consisting of 75 per cent. of wheat flour and 25 per cent. of very finely ground soy-bean meal. This mixture is used quite successfully in the preparation of "soya bread" and "soya biscuits." The former is claimed to be a better balanced food than ordinary wheat bread, and the latter are stated to be very palatable.

For this purpose extracted meal has been found to be preferable to powdered cake, the quantity of oil in the latter making the bread too heavy for ready digestion.

Biscuits composed of ground-nut meal, made from the blanched kernels, and maize meal, have been manufactured recently, and an attempt has already been made to place them on the London market.

GROUND-NUT SHELLS

The shells contain as much as 59 per cent. of crude fibre, and their total digestibility is only

16 per cent. (Kellner). They have, therefore, very little value as food. In many factories they are burnt as fuel and the ashes are used as manure. They are sometimes, however, at any rate in Germany, ground in with the cake; this does not perceptibly alter the colour of the cake, and it is claimed that a certain proportion of fibre is beneficial in concentrated foods, as it assists in providing the necessary volume for the animals' digestion to work upon.

Ground-nut shells are also used in the preparation of "compound cakes," for mixing with foods of high value, notably in molasses foods, their use being alleged to be for the purpose of giving the necessary "body."

It is to be noted that shells coming from a decorticator have a higher food value than is generally shown in analyses, as they contain fragments of kernels accidentally broken in the machine.

GROUND-NUT BRAN

The thin red pellicles immediately covering the kernels contain on an average 14 per cent. of oil (C. S. Fuchs, *Chem. Zeit.*, 1911, p. 358). Mixed with a greater or less proportion of ground shells, they are known commercially in Germany as ground-nut bran. The ground shells, with only a small proportion of pellicles, or even with none at all, are sometimes put forward under that name.

A more genuine bran consists of the pellicles together with only 20 or 30 per cent. of material from the inside of the shells, and also a small proportion of fragments of kernels, the whole being ground to the appearance of ordinary bran. This material is stated by the American Consul-General at Hamburg to contain 14-18 per cent. of oil, and there has long been a market for it in Germany. It was quoted in November 1913 at £2 4s. to £2 8s. per ton, delivered at Hamburg, gross for net, sacks included. The inferior bran, made from the outer shells, was quoted at about £2 per ton.

GROUND NUTS FOR EDIBLE PURPOSES

Lastly, the ground-nut kernel itself is valuable as an article of human food. Its high protein content makes it especially valuable as a flesh and muscle former. The following analyses (p. 76) of nuts and other foods of high nutritive value are quoted from Professor A. H. Church (*"Food." South Kensington Museum Science Handbook*), except those of sweet almonds and chestnuts, which are from Dr. R. Hutchinson (*Food and the Principles of Dietetics*). The nutrient ratios and food units are calculated as explained in the section on ground-nut cake (pp. 69, 70).

Ground nuts are eaten in a great variety of ways. In West Africa and other countries where the plant is grown, the kernels are often used as a vegetable, especially in the form of ground-nut

soup, and their use in this way in Europe might be largely extended. In the United States they are largely eaten. As a dessert nut they are extremely popular under the name of "peanuts." They are sometimes eaten as such, but more often the kernels are salted and roasted before

	Water.	Proteins.	Oil.	Carbo- hydrates.	Cellulose.	Mineral matter.	Nutrient ratio.	Food units.
	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.		
" NUTS "								
Ground-nut ker- nels . . .	7.5	24.5	50.0	11.7	4.5	1.8	1 : 5.17	198.0
Sweet almonds (shelled) . .	6.0	24.0	54.0	10.0	3.0	3.0	1 : 5.59	205.0
Pistachio ker- nels . . .	7.4	22.7	51.1	13.0	2.5	3.3	1 : 5.75	197.5
Walnut kernels (peeled) . .	44.5	12.5	31.6	8.9	0.8	1.7	1 : 6.53	119.2
Hazel- (filbert) nut kernels	48.0	8.4	28.5	11.1	2.5	1.5	1 : 9.12	103.4
Chestnuts . .	38.5	6.6	8.0	45.2		1.7	1 : 9.18 ¹	78.7 ¹
PULSES :								
Lentils (husked)	12.5	25.0	2.0	56.1	1.9	2.5	1 : 2.43	123.6
Haricot beans	14.0	23.0	2.3	52.3	5.5	2.9	1 : 2.50	115.6
Peas . . .	14.3	22.4	2.5	51.3	6.5	3.0	1 : 2.55	113.6

¹ Assuming 3 per cent. of cellulose.

use. In America, the street vendor of roasted peanuts is as familiar a sight as the purveyor of roasted chestnuts in the streets of London. The kernels are also eaten in peanut candies, in combination with popcorn and puffed rice, and are used in a variety of other confectionery preparations. They are also finely ground to a paste known as "peanut butter," and are used in the

preparation of peanut meal and of various so-called "vegetable meats."

For dessert purposes the kernels are first roasted, and then the thin brown coverings are removed; next the halves are separated and the small embryo plants removed; finally they are submitted to a blanching process to prepare them for table use. In the manufacture of "peanut butter" the shelled kernels are gently roasted, and then fanned and screened to remove the brown coverings and "germs" (embryo plants). They are then ground to a pulp by means of special machinery; the pulp is fed into bottles or tins holding from a quarter of a pound to five pounds, and hermetically sealed. Salt is sometimes added in the process of manufacture. It is stated that with a small meat-grinder and a little experience, "peanut butter" may readily be made at home.

Peanut "meal," made from the ground blanched kernels, is used in the preparation of macaroons and small cakes.

For further information on ground nuts as an article of food, references may usefully be made to the American trade publications.

In England, ground nuts are already used in some preparations of confectionery, *e.g.* as substitutes for pistachio nuts and sweet almonds in the manufacture of nougat and marzipan. They are bought and eaten raw by children under the name of "monkey nuts," but they have not yet attained the popularity which they enjoy in America. It should not, however, be a difficult matter to

enlarge the market for them ; and in view of the increasing popularity of "nut foods" it should be possible to use them in much larger quantities in this country, in preference to the various kinds of edible nuts now imported from foreign countries.

SESAME SEED

SESAME (*Sesamum indicum*) is an annual plant, grown throughout the tropics and sub-tropics. The seed is known in commerce under a number of other names, *e.g.* sim-sim or sem-sem, til or teel, gingelly or jinjilli, and benne or benni. The oil obtained from the seed, as well as the seed itself, is used in the countries of production as a food, and is extensively employed in European countries and the United States in soap-making and the preparation of edible oils and fats, whilst the residual cake is largely used on the Continent as a food for cattle.

The plant is cultivated throughout the warmer regions of the world, but the seed is produced on a large scale for export in comparatively few countries, of which India and China are by far the most important. In most countries the greater part of the crop is consumed locally. The following table shows the exports of sesame seed from the chief producing countries in the last year for which statistics are available:

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	Quantity. cwts.	Value. £
India (1913-14) . . .	2,244,019	1,796,841
Sudan (1913) . . .	134,626	107,672
East Africa Protectorate		
(1913-14) . . .	76,198	58,564
Uganda (1913-14) . . .	17,919	10,449
China (1913) . . .	2,422,200	1,868,717
Indo-China (1912) . . .	17,592	8,939
Portuguese East Africa		
(Porto Amelia) (1912) . . .	26,180	13,689
German East Africa (1912)	36,880	26,186
Turkey ¹ (1912) . . .	240,000	—

The most valuable seed is that produced in the Levant, the Bombay white seed coming next, the Chinese and African seed being of lowest value.

The following table shows the price of various grades of sesame seed in Marseilles and Hamburg previous to the War :

	Marseilles, July 1, 1914. Per ton.	Hamburg, June 20, 1914. Per ton.
Jaffa Levant	£23 3s.	
Bombay white	£17 5s.-£17 13s.	
West African		£15 5s.-£15 15s.
East African		£15 10s.-£16

¹ Complete statistics for the export of sesame seed from Turkey are not available ; the figure given represents the exports from the following ports of Syria and Asia Minor : Haifa, Jaffa, Mersina, Adalia, Ayas and Smyrna.

According to trade regulations, consignments of sesame seed must contain less than 25 per cent. of dark seed in order to be classed as "white," whilst allowances have to be made if more than 15 per cent. of dark seed is present. Mixtures of dark and white seed are classed as "bigarré," which must contain at least 35 per cent. of white seed. Mixtures of large and small seed are also subject to certain regulations and allowances.

UTILISATION OF SESAME SEED

Sesame seed is largely used in the countries of production as a foodstuff. In Egypt, India and the East, it is widely consumed in the form of sweetmeats. In Turkey a sweetmeat called "Halva" is made by grinding the seeds with sugar and then cooking. In these countries the seeds are also crushed in crude mills or presses, and the oil so obtained is used in cooking, for mixing with "ghi" (butter fat) in India, for the preparation of perfumed oils, and for burning and other minor uses; the residual cake is employed as a cattle food, or even for human food in time of scarcity.

Comparatively little sesame seed is at present imported to the United Kingdom, and this is stated to be entirely employed as a component of compound feeding cakes, for the purpose of bringing the percentage of oil up to standard.

THE TRADE IN SESAME SEED

Until within the last few years the principal market for sesame seed was France, but Germany has recently considerably increased its consumption of the seed, and in 1913 the quantity imported into the latter country was four times that imported into France, whilst Austria-Hungary in that year imported almost as much as France. The quantity and value of the imports into these three countries in 1913 are shown in the following tables :

IMPORTS OF SESAME SEED INTO FRANCE, 1913

From	Quantity. Metric tons.	Value. £
India	22,819	1,000,000
Egypt	1,199	100,000
British East Africa	1,186	100,000
Other countries .	2,613	100,000
TOTAL	27,817	500,690

IMPORTS OF SESAME SEED INTO GERMANY, 1913

From	Quantity. Metric tons.	Value. £
India	32,024	1,000,000
China	79,060	1,000,000
Other countries .	4,955	100,000
TOTAL	116,039	2,075,950

IMPORTS OF SESAME SEED INTO AUSTRIA-HUNGARY,
1913

From	Quantity. Metric tons.	Value. £
India . . .	22,098	427,220
China . . .	3,415	66,025
Turkey . . .	1,106	21,377
Other countries . .	10	211
TOTAL . . .	26,629	514,833

Large quantities are also imported into Belgium and Italy. As already mentioned, only small quantities of sesame seed have up to the present been imported into the United Kingdom.

It will be seen from the above tables that in the

EXPORTS OF SESAME SEED FROM INDIA

To	1911-1912.		1912-1913.		1913-1914.	
	cwts.	£	cwts.	£	cwts.	£
United Kingdom . .	727	533	1,018	714	6	4
British possessions (including Egypt) . .	64,050	42,574	88,923	66,141	73,354	53,459
Germany . .	212,210	153,461	171,819	131,944	330,208	270,887
Belgium . .	420,736	300,563	351,702	279,599	675,586	557,532
France ¹ . .	449,585	315,098	434,503	341,841	444,143	344,258
Italy . .	260,640	189,185	108,549	81,774	285,868	222,749
Austria-Hungary . .	447,679	321,180	381,356	298,357	386,842	310,290
Other foreign countries . .	40,764	28,180	19,301	15,413	48,012	37,662
TOTAL . .	1,896,391	1,350,861	1,557,171	1,215,783	2,244,019	1,796,841

¹ In 1910-11 1,681,597 cwts., of value £1,087,577, were exported to France out of a total of 3,246,530 cwts., valued at £2,135,539.

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case of France and Austria-Hungary over 80 per cent. of the seed came from India, and in the case of Hamburg over 40 per cent. In addition a very large proportion of the seed imported into Belgium was derived from India, so it is obvious that at the present time very large quantities of Indian seed are available for new markets. This is also evident from a consideration of the table on page 83 showing the exports of sesame seed from India during recent years.

The actual effect of the war on the export of sesame seed from India is shown in the following table, which gives the quantity exported to the chief European countries during the seven months September 1913 to May 1914, and during the corresponding period of 1914-15.

	September 1913- May 1914. cwts.	September 1914- May 1915. cwts.
Germany . . .	258,792	Nil.
Belgium . . .	604,093	Nil.
France. . . .	445,466	98,104
Italy	289,342	64,340
Austria-Hungary	347,742	Nil.
Other countries	168,154	79,721
TOTAL . . .	2,113,589	242,165

The position is not quite so serious in the case of other British countries exporting sesame seed, details of the exports of which are shown in the following tables :

SESAME SEED

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SUDAN

	1911.		1912.		1913.	
	cwts.	£	cwts.	£	cwts.	£
United Kingdom	—	—	7	5	5	4
Egypt . . .	75,201	57,354	92,065	69,852	109,236	87,768
Austria-Hungary	3,273	2,401	1,359	992	269	210
Belgium . . .	1,578	1,142	—	—	5,798	4,535
France . . .	14,596	10,700	19,925	15,301	9,611	7,487
Germany . . .	6	4	4,495	3,516	4,912	3,925
Italy . . .	—	—	—	—	1,727	1,420
Turkey . . .	1,693	1,254	1,704	1,428	21	12
Other countries.	787	572	408	315	3,047	2,312
TOTAL .	97,134	73,427	119,963	91,409	134,626	107,672

EAST AFRICA PROTECTORATE

The following figures represent the exports of sesame seed produced in the Protectorate; the total exports, including re-exports, in 1913-14 amounted to 96,386 cwts., valued at £74,146.

	1911-1912.		1912-1913.		1913-1914.	
	cwts.	£	cwts.	£	cwts.	£
United Kingdom .	172	117	1,269	986	2,830	2,209
India . . .	1,577	1,077	11,041	8,343	14,072	11,033
Zanzibar . . .	4,558	2,897	1,849	1,338	4,617	3,691
Austria-Hungary	2,403	1,528	—	—	370	298
Belgium . . .	5,638	3,715	—	—	—	—
France . . .	33,706	22,255	29,639	21,494	6,192	4,731
Germany . . .	2,181	1,410	6,272	4,523	14,740	11,021
Holland . . .	—	—	2,327	1,775	8,834	6,841
Italy . . .	4,221	2,849	19,962	14,945	11,166	8,413
Other countries .	14,456	9,151	8,102	5,719	13,377	9,727
TOTAL . .	68,771	44,999	80,461	59,123	76,198	58,564

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UGANDA

The destination of the sesame seed exported from Uganda is not given in the Official Statistics. The total exports in recent years are as follows :

		1911-12.	1912-13.	1913-14.
Quantity	cwts.	13,955	31,408	17,919
Value .	£	7,048	16,812	10,449

NIGERIA

	1911.		1912.		1913.	
	cwts.	£	cwts.	£	cwts.	£
United Kingdom .	9,236	3,704	8,816	2,671	20,744	7,827
Germany . . .	123	39	633	301	1,516	713
France . . .	—	—			2,015	705
TOTAL . . .	9,359	3,743	9,449	2,972	24,275	9,245

SIERRA LEONE

	1911.		1912.		1913.	
	cwts.	£	cwts.	£	cwts.	£
United Kingdom .	108	58	15	8	49	37
Ivory Coast . .	—	—			8	7
Germany . . .	1,839	1,156	340	206	201	115
France . . .	163	90	35	19	257	171
Conakry . . .	100	52	520	322	200	130
TOTAL . . .	2,210	1,356	910	555	715	460

SESAME OIL

Sesame seeds are rich in oil, generally containing from 50 to 57 per cent.; on a large scale the yields obtained by expression from various commercial varieties are as follows:

Kind of seed.	Yield of oil Per cent.
Bombay, yellow, or red . . .	44-45
„ bigarré . . .	42-44
Levant	47-48
Chinese	44-45

On account of their richness in oil, the seeds are usually pressed once or twice cold and once hot. In most of the Marseilles factories the seeds, after being dried more or less completely in mechanical driers, are ground and then pressed for one to one and a half hours, the yield of oil being from 32 to 35 per cent. The residue is then ground with the addition of 4-5 per cent. of water and again pressed in the cold, when about 5 to 6 per cent. of oil is obtained. The same quantity of water is again added and the ground residue pressed at a temperature of 45° to 50° C. The third pressing gives a yield of 9 to 10 per cent. of oil. In the case of certain varieties of sesame only two pressings are given, whilst in Germany as a rule all three pressings are made in the cold. The residual cake still contains a certain amount of oil, and this is sometimes extracted by a solvent such as carbon disulphide.

Sesame oil obtained from the first pressing is an odourless, yellow, clear oil, without pronounced flavour, that from the second pressing is darker and of stronger flavour. The inferior oil is frequently refined, and it then approaches that obtained from the first pressing in quality. The oil from the third hot pressing is of dark colour, disagreeable flavour, and is strongly acid. It is occasionally refined by the addition of an alkali, and the purified oil is then classed with that from the second pressing.

The finest oil is obtained from Levant seed, the best of which is that from the Jaffa district. Oil from Indian seed is stated to be less pleasant in flavour than that from Levant seed, whilst Chinese and African seed yield the lowest grades of oil.

Sesame oil is usually classed as a semi-drying oil, and only exhibits a slight tendency to dry when spread out in thin films and exposed to light and air. If well prepared it is not liable to develop rancidity.

The best grades of sesame oil are used as substitutes for olive oil, either alone or in admixture with other oils. This quality of oil is official in the British Pharmacopœia for use in India and the Colonies in place of olive oil. It is also included in the Japanese, Russian and other pharmacopœias as a substitute for olive oil in medicine. It is employed to a large extent in the preparation of margarine and vegetable butters, the amount used annually in this way in Northern Europe being estimated at 32,000 tons. In this con-

nection it has been already pointed out that in some Continental countries it is compulsory to employ a certain percentage of sesame oil in the manufacture of margarine, as this oil can be easily detected by appropriate tests, thus rendering it easy to discriminate between margarine and butter.

The lower qualities of oil are employed in soap-making and for lubricating and illuminating purposes.

The cake which is produced by the crushing of damaged seed is generally unsuitable for use as a feeding-stuff, and it is usually extracted with carbon disulphide in order to obtain the oil left in it. This extracted oil is employed in the manufacture of Marseilles mottled soap, and, after removal of the fatty acids, as a lubricating or burning oil.

The following table shows the prices of various grades of sesame oil in Marseilles on July 1, 1914 :

Kind of oil.	Price per ton.			
	£	s.	£	s.
Jaffa "extra" . . .	42	0	to 43	0
Indian "extra" . . .	36	10	„ 38	0
„ "superfine" . . .	34	10	„ 35	0
Illuminating oil . . .	32	10	„ 33	0
Prepared by extraction with carbon disulphide .	24	10	„ 25	0

Since the outbreak of war the price of sesame oil has advanced, that from white Bombay seed being quoted at £40 per ton in Marseilles in May 1915.

SESAME CAKE

The residual cake which is left after the oil has been expressed forms a very nutritious feeding-stuff for cattle, and is in considerable demand for this purpose on the Continent. According to Thompson (*loc. cit.*), over 51,000 metric tons of the cake were produced in Germany in 1912, the total consumption in that country amounting to 150,000 metric tons.

The average composition of sesame cake is shown in the following table, compared with that of other feeding-stuffs in common use in the United Kingdom:

CRUDE NUTRIENTS

	Moisture.	Crude proteins.	Fat.	Carbo-hydrates (by difference).	Crude fibre.	Ash.	Nutrient ratio.	Food units.
	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.		
Sesame cake .	8.12	30.60	13.01	22.00	4.36	12.91	1 : 1.31	154
Linseed cake, English made, average (expressed) .	11.6	29.50	9.50	35.51	9.10	5.20	1 : 1.94	133
Linseed meal (extracted) .	13.15	34.75	5.03	34.67	8.75	5.65	1 : 1.20	129
Decorticated cotton-seed meal. Atlantic ports (expressed) .	7.40	42.37	10.16	25.86	7.06	7.15	1 : 1.16	157
Undecorticated cotton-seed cake English made (expressed) .	13.75	24.62	6.56	29.28	21.19	4.60	1 : 1.67	107

The proportion of digestible nutrients in sesame cake as compared with the other cakes, together with the feeding value as expressed in food units calculated by the method referred to on p. 23, is given below.

DIGESTIBLE NUTRIENTS

	Crude proteins.	Fat.	Carbo- hydrates.	Crude fibre.	Food units.
	Per cent.	Per cent.	Per cent.	Per cent.	
Sesame cake	35·64	11·71	12·32	1·35	77
Linseed cake, English made, average (expressed)	25·37	8·74	27·72	2·91	75
Linseed meal (extracted)	29·19	2·88	28·45	4·70	67
Decorticated cotton-seed meal, American ports (ex- pressed)	36·44	9·55	17·33	1·98	77
Undecorticated cotton-seed cake, English made (ex- pressed)	18·96	6·10	15·23	3·80	46

The figures given in these tables show clearly that sesame cake compares favourably with the best feeding cakes at present commonly used in this country. In addition to the fact that it is consumed largely on the Continent, its value as a feeding-stuff has been demonstrated by numerous feeding trials, both in the United Kingdom and on the Continent.

Experiments conducted at the South-Eastern Agricultural College, Wye, with milch cows showed the cake to be an excellent fodder of pleasant taste; the stock liked it and took up to 7 lb. or 8 lb. a day per head with no ill effects. The butter was soft and white. No trace of sesame oil

was found in the butter, which confirms the results of other trial experiments.

Although the experiments at Wye showed that 7 lb. to 8 lb. of cake may be fed per day without ill effects, it would seem that in the case of milch cows the amount should not exceed 2 lb. to 3 lb. per day. Moses, Peter and Kappeli state (*Jahresber. Molk. Schule Rutti-Zollikofen*, 1904-5, 18, Beilage) that sesame meal to the extent of 1 kilogram (2.2 lb.) per head per day produced a satisfactory increase in the yield of milk, but when the amount was increased to 1½ kilograms the yield was relatively less satisfactory. In the experiments recorded by these authors, the amount of fat in the milk showed no marked variations due to the feeding. The cheese was apparently influenced unfavourably by the larger quantities of meal used, but the butter was regularly of good quality. N. Hansson (*Med. Centralanst. Försöksv. Jordbruksområdet*, 1911, No. 47, p. 4) also found that sesame cake increased the yield of milk, but as a large quantity decreases the amount of fat, he recommends that not more than 1 to 1½ kilograms be given daily to one cow.

MOWRA SEED

MOWRA or Mowa seeds, the source of the Mowra fat of India, are the product of the two principal Indian species of *Bassia* (Natural Order: Sapotaceae), viz. *Bassia latifolia* and *Bassia longifolia*. Other less common species of *Bassia*, however, also furnish seed containing large quantities of fat.

B. latifolia grows chiefly in Central and East India, and not in the South, whilst *B. longifolia* only grows in Southern India and Ceylon. According to Watt the trees are known by the same native names, viz. "mahua," "mahwa" or "mowha" (Hindustani), and "illupei," "illupai," or "illipi" (Tamil), but in consequence of their geographical distribution *B. latifolia* is generally known by the Hindustani names and *B. longifolia* by the Tamil names. Indeed, it is commonly stated that the true mowra fat is the product of *B. latifolia*, that of *B. longifolia* being illipi fat. This generalisation, however, is not always true. The two species of seeds resemble one another not only in appearance, but also in the nature of the fats which they yield, and the mowra fat of commerce is frequently the mixed product of both.

In Ceylon, mowra fat is known by the Sinhalese name "mi" or "mee" (though the Tamil name is also used), and it is there exclusively the product of *B. longifolia*.

In this article the name mowra is applied to the products of both trees, and the name illipi is discarded altogether, a procedure which is specially desirable in view of the fact that the latter name (often spelt "illipe"), generally with a variety of prefixes, is applied in commerce to a number of seeds or nuts derived from trees of a different family in the Malay Archipelago, and are sources of an entirely different fat known as Borneo tallow.

Both trees which yield mowra fat grow wild, but are also to some extent cultivated. Both flourish best on dry soil. The seeds, or nuts, are harvested about the end of May and beginning of June.

Another Indian species of *Bassia* is *B. butyracea* (native name: "phulwara"), which occurs in the sub-Himalayan tracts from the Ganges to Bhutan, and grows up to altitudes of 15,000 feet; this yields the fat known as "phulwa," which is very similar to mowra fat, though somewhat harder.

The seeds of the three species resemble one another in appearance, but differ in size, *B. butyracea* being the smallest and *B. longifolia* the largest. The last-named are also of a much more elongated shape than the others.

THE TRADE IN MOWRA KERNELS

There is a considerable demand for the kernels in all parts of India, but there remains an annual margin for export. The following export figures, however, show that this margin is distinctly fluctuating, as are also the present demands from the various importing countries. The figures are of interest, especially as showing how much Germany has taken and how little has been taken by this country :

EXPORT OF MOWRA KERNELS (*B. LATIFOLIA* AND *B. LONGIFOLIA*) FROM INDIA

Destination.	1909-10.	1910-11.	1911-12.	1912-13.	1913-14.
	cwts.	cwts.	cwts.	cwts.	cwts.
United Kingdom	6,021	32,325	6,060	—	—
Egypt . . .	—	1,200	—	—	—
Other British Possessions .	—	—	—	3	25
Germany . . .	400,500	261,196	559,982	187,054	567,670
Belgium . . .	170,370	71,494	146,512	61,109	88,792
France . . .	198,008	44,437	63,571	3,062	8,492
Holland . . .	—	—	3,000	14,632	1,000
Italy . . .	9,085	5,010	16,000	1	—
Other foreign countries .	47	—	1	—	—
Total quantity	784,037	415,662	795,126	265,861	665,979
Value £	311,421	207,357	392,350	142,913	363,634

The kernels of *B. butyracea* are nearly all used in India for the preparation of edible fats, hardly

any being exported. If obtainable in quantity, these seeds would find important uses in Europe.

Mowra kernels were quoted in Marseilles before the war (April 1914) at £11 16s. per ton.

NATURE AND USES OF MOWRA FATS

The seeds of the three species of *Bassia* under consideration have been examined at the Imperial Institute, and a full account of the investigation will be found in the *Bulletin of the Imperial Institute*, 1911, vol. 10, p. 228.

The proportion of fat in the kernels of *B. latifolia* and *B. longifolia* is somewhat variable, but averages about 55 per cent.; that in the kernels of *B. butyracea* is generally about 65 per cent.

Mowra fat, when properly prepared, is soft and yellowish, becoming bleached on keeping. As made by natives, it is generally dirty and of a greenish colour. Phulwa fat is harder, and is white when properly prepared. The fats are pleasant in taste and smell when prepared by European methods.

It will be seen that if a regular supply of any of these *Bassia* seeds could be depended on from India, which is not at present the case, they would supply the source of a vegetable fat which would be of value for the manufacture of margarine and vegetable butters. It is probable that the cake could be so treated as to render it suitable for use

as a food for animals. If so, the value of the seeds would be considerably enhanced.

Mowra fat is largely used for edible purposes in India, as a substitute for tallow, and for mixing with "ghi" as well as for cooking, burning and soap-making. In Europe it is chiefly used in the manufacture of soap and candles. It is also stated to be used as a chocolate fat, and its use for the last-named purpose, as well as for other edible purposes, could probably be extended.

Mowra seeds have within recent years been crushed in Hull in fairly large quantities, but reference to the Indian export tables shows that latterly they have not been brought to this country, and that an increasingly large proportion of the total quantity available has gone to Germany. Probably one reason for the discontinuance of the British demand is that importers find they cannot depend on large or even regular supplies; and it is to be hoped that the cessation of trade with Germany consequent upon the war will result in the diversion to the United Kingdom of supplies which formerly went to that country.

Phulwa fat is used for edible purposes in India, generally in admixture with "ghi." It would be very well suited for edible purposes in Europe if properly prepared, and would probably command a higher price than Mowra fat on account of its harder consistency.

For soap-making these fats have about the same value as good palm oil. If suitable for edible purposes their value is much greater.

MOWRA CAKE AND MEAL

The cake left after removal of the fat from Mowra kernels by crushing or extraction, is unsuitable for use as a cattle-food, owing to the fact that it contains the poisonous glucoside saponin, and its chief use is as a manure. In France it is used exclusively for this purpose, but in Germany it is also used in admixture with other foods for animals, especially molasses foods, and processes have been patented for making it edible. It is believed to be used as a dressing for lawns and golf-greens for the purpose of destroying worms, the saponin which it contains rendering it very efficacious for this purpose. It could probably also be used in the preparation of insecticide dressings for hops and fruit trees, and for other horticultural purposes. // In Ceylon it is baked and used as a hairwash, the saponin giving it detergent properties.

An analysis of the meal by Honecamp, Reich and Zimmerman (*Landw. Vers. Stat.*, 1912, vol. lxxviii., Parts V.-VI., pp. 321-346) gave the following composition :

	Per cent.
Water .	14.00
Proteins .	17.12
Fat .	2.17
Carbohydrates	53.55
Crude fibre	5.62
Ash .	7.54

The percentages of manurial constituents in the meal, according to the same authors, are :

Nitrogen .	2·57
Phosphoric acid	1·01
Potash .	3·41

Its value as a manure applied directly to the land is, therefore, £2 15s. 3d. per ton at the ordinary values of these constituents.

The quantity of saponin in the meal is stated (*loc. cit.*) to be from 29 to 31 per cent., and a cheap process for the removal of this constituent will have to be found before the meal can be employed as a food for animals.

COMPARATIVE FEEDING VALUES OF COCONUT, PALM KERNEL, GROUND NUT, AND SESAME CAKES

IN order to obtain some idea of the relative feeding values of the cakes dealt with in these monographs, their composition may be conveniently tabulated in comparison with feeding cakes already in common use in this country. For this purpose it is best, as already explained, to employ the percentages of digestible constituents present; the value, expressed in food units, is also calculated on these constituents.

	Proteins.	Fat.	Carbo- hydrates.	Fibro.	Food units.
	Per cent.	Per cent.	Per cent.	Per cent.	
Coconut cake . . .	19.1	8.1	33.0	8.1	76
Palm-kernel cake . . .	12.84	6.12	37.30	4.98	66
Ground-nut cake . . .	39.60	10.10	23.63	0.29	88
Sesame cake . . .	35.64	11.71	12.32	1.35	77
Linseed cake . . .	25.37	8.74	27.72	2.91	75
Uncorticated cotton- seed cake . . .	18.96	6.1	15.23	3.8	46

These figures show that ground-nut cake is of considerably higher feeding value than any of the other cakes; sesame and coconut cakes are richer than linseed cake, and all of them very

much more valuable than undecorticated cotton-seed cake. Taking the price of English-made linseed cake at £11 per ton, the price per food unit per ton is 2s. 4d., after making due allowance for the manurial value of the residue arising from the consumption of 1 ton of the cake. On this basis the value of coconut cake would be about £10 11s. 11d. per ton, palm-kernel cake £8 16s. 11d., ground-nut cake £13 11s. 6d., and sesame cake £11 16s. 1d. All the cakes, therefore, are comparatively cheap at recent market prices, which are as follows, the prices of cotton and linseed cakes being added for comparison :

	Per ton.
Coconut cake, London	£7 15s.
Palm-kernel cake, English made,	
Liverpool	£5 15s.—£6
Ground-nut cake, London	£7 15s.—£8 15s.
Sesame cake, London	£5—£6
Linseed cake, English made, Liver-	
pool	£12 10s.—£12 15s.
Cotton-seed cake, decorticated,	
English made, Liverpool	£11—£11 10s.
Cotton-seed cake, undecorticated,	
English made, Liverpool	£8—£8 5s.

APPENDIX

BOARD OF AGRICULTURE AND FISHERIES

(Special Leaflet No. 20)

COCONUT CAKE AND PALMNUIT KERNEL CAKE

COCONUT cake and palmnut kernel cake are two feeding stuffs which are being brought prominently to the notice of stock owners as a result of the war. The main reason for this is that part of the large quantities of the raw products from which these cakes are manufactured—viz., “copra” and palmnut kernels respectively, which were formerly exported to Germany and Austria-Hungary has now been diverted to the United Kingdom. A certain amount of coconut cake is manufactured in England, but hitherto practically all the palmnut kernels produced in Nigeria and other British Colonies have been exported to Germany.

Further, the closing of the German market has made it necessary for such parts of the Empire as depend largely on the export of copra and palmnut kernels to find new markets, and efforts are being made to establish new coconut and palmnut kernel crushing industries in the United Kingdom. The success which might attend the establishment of such industries would partly depend (at any rate during the continuance of the war) on the extent to which the cakes could be disposed of to British farmers who purchase very large quantities of feeding stuffs, and are always

ready to utilise new oil cakes if they can be shown to be good value.

Experiments with one or other of these cakes are being undertaken at a number of Agricultural Colleges, but the results will probably not be available for some time. For this reason the results of such few English experiments as have already been conducted have had to be supplemented from German sources of information.

Copra and palmnut kernels are obtained by removing the shell from the coconut and palmnut respectively. The principal products obtained from the crushing of copra and palmnut kernels are coconut oil and palmnut oil respectively, these being used in the soap industry and in the manufacture of butter substitutes, chocolate fats, and various other edible fats.

The oil is obtained either by pressing the copra and palmnut kernels or by extraction with chemical solvents. In the former case the residues mostly take the form of cake; in the latter case, when the copra or palmnut kernels are ground the residues take the form of meal.

The composition of the cakes naturally varies with the efficiency of the crushing process employed to express the oil, and as the process improves the resulting cakes tend to show a lower percentage of oil and a correspondingly larger percentage of other nutrients than cakes produced by the older methods. When the oil is extracted by solvents, much less is left in the residue than would be left by the crushing process.

Analyses

The following tables show, for coconut and palmnut kernel cakes, the average of a large number of analyses

given by various experimenters, together with the minimum and maximum figures found for each individual constituent :

COCONUT CAKE (CRUDE NUTRIENTS)

(Average of 25 analyses, many of which are themselves averages)

	Molsture.	Oil.	Crude Protein.	Carbo-hydrates.	Crude Fibre.	Ash.
	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.
Minimum	4.17	7.20	17.87	25.92	7.04	4.10
Maximum	13.16	21.96	24.50	48.00	20.60	9.55
Average	10.05	11.18	20.80	39.09	12.51	5.95

PALMNUT KERNEL CAKE (CRUDE NUTRIENTS)

(Average of 11 analyses, some of which are themselves averages)

	Molsture.	Oil.	Crude Protein.	Carbo-hydrates.	Crude Fibre.	Ash.
	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.
Minimum	9.70	4.40	15.89	33.40	10.00	3.55
Maximum	13.40	12.91	19.12	50.00	24.98	4.00
Average	11.06	7.90	17.15	41.54	18.29	3.83

For purposes of comparison the composition of average samples of the commoner feeding cakes are given below :

	Molsture.	Oil.	Crude Protein.	Carbo-hydrates.	Crude Fibre.
	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.
Linseed Cake . . .	12	10	30	34	9
Decorticated Cotton Cake	8	9	41	26	8
Undecorticated Cotton Cake	12	5½	22	34	20

The approximate prices for the various cakes named in Liverpool in the middle of January were as follows, per ton: Linseed cake, £11; decorticated cotton cake, £9 5s.; undecorticated cotton cake, £6; coconut cake, £7 18s. 9d.; palmnut kernel cake, £6 8s. 9d. On the basis of these figures, and of the average crude nutrients given above, the price per food unit¹ (crude, and disregarding fibre) would average about 1s. 7½d. for linseed cake; 1s. 2½d. for decorticated cotton cake; 1s. 2d. for undecorticated cotton cake; 1s. 4d. for coconut cake; and 1s. 2¼d. for palmnut kernel cake.

Digestibility

The following results of digestibility experiments are given by various German authorities (per cent.):

DIGESTIBILITY COEFFICIENTS

	Organic Sub- stances.	Oil.	Crude Protein.	Carbo- hydrates.	Crude Fibre.
COCONUT CAKE					
<i>Ruminants:</i>					
Kellner . . .	80	97	78	83	63
Pott . . .	—	100	81	84	—
<i>Pigs:</i>					
Kellner . . .	80	83	73	89	60

¹ The number of food units is obtained by multiplying the oil and albuminoids by 2½ and adding to the carbohydrates. This assumes that the differences in the manure values will be sufficiently allowed for in the high value assigned to the albuminoids (see also Leaflet No. 74, *The Composition and Properties of Concentrated Feeding Stuffs*).

	Organic Sub- stances.	Oil.	Crude Protein.	Carbo- hydrates.	Crude Fibre.
PALMNUIT KERNEL CAKE					
<i>Ruminants :</i>					
Kellner .	70	98	75	77	39
<i>Pigs :</i>					
Kellner .	68	78	69	77	36
<i>Sheep :</i>					
Weiniger (<i>Kuchen- mehl</i>) . . .	77	79	77	89	39

LINSEED CAKE, DECORTICATED COTTON CAKE AND UNDECORTI-
CATED COTTON CAKE

<i>Ruminants :</i>					
Kellner—					
Linseed Cake	79	92	86	78	32
Decorticated Cotton Cake .	76	94	86	67	28
Undecorticated Cot- ton Cake .	55	93	77	52	18

As regards digestibility of total organic matter, coconut cake is equal to linseed cake, and ranks above decorticated cotton cake, while palmnut kernel cake falls below decorticated cotton cake.

Applying Kellner's digestibility coefficients for ruminants to the average analyses given on p. 104, the proportion of digestible nutrients of coconut cake and palmnut kernel cake, with the corresponding figures for the commoner cakes, would be approximately as follows:

	OIL.	Crude Protein.	Carbo- hydrates.
	Per cent.	Per cent.	Per cent.
Coconut Cake	10.84	16.22	32.44
Palmnut Kernel Cake . . .	7.74	12.86	31.99
Linseed Cake	9.20	25.80	26.62
Decorticated Cotton Cake .	8.46	35.26	17.42
Undecorticated Cotton Cake	5.11	16.94	17.68

On the basis of their digestible nutrients the price per food unit¹ would be about 1s. 7d. for coconut cake, and 1s. 6½d. for palmnut kernel cake, compared with about 1s. 5½d. for decorticated cotton cake, 1s. 8d. for undecorticated cotton cake, and 1s. 11d. for linseed cake.

In considering the digestibility of a food, the amount of fibre and its condition must be taken into account. The amount of crude fibre in both coconut and palmnut kernel cakes (especially the latter) seems to be well above that found in linseed and decorticated cotton cakes; but the fibre of coconut and palmnut kernel cakes (especially the former) appears to be much more digestible than that of the two latter cakes. In the most recently made samples of palmnut kernel cake the proportion of fibre is not very much more than that found in linseed cake.

Coconut Cake and Palmnut Kernel Cake as Foods for Stock

Palmnut kernel cakes in the past have had the reputation of soon going rancid, and this is generally ascribed to an excess of oil present. At the present day, before the kernels are crushed they are subjected to a process of cooking, by which the ferment that causes the oil to turn rancid is rendered inactive; if palmnut kernel cake is stored in a suitable, dry place, there is little danger of fermentation taking place.

When cakes contain a very low percentage of oil the great pressure which has been employed makes the cake excessively hard and renders full utilisation by stock difficult. Specific effects are ascribed to the oil (see later), so that from this point of view also the

¹ See footnote on p. 105.

percentage of oil should not be too low. In any case it is not advisable for users of palmnut kernel cake to lay in large stocks; and the cake should be kept unbroken until actually needed for feeding to stock.

These considerations as to the oil content of palmnut kernel cake probably apply also in great measure to coconut cake.

Good samples of coconut cake are bright red or brown to brownish grey in colour, while those of palmnut kernel cake are of a whitish grey colour. Adulteration is not common.

When gradually accustomed to the foods both kinds of cake seem to be readily eaten by all classes of stock. They are mostly fed dry. When prepared with warm water palmnut kernel cake has an unpleasant taste; if it is moistened at all it should not be allowed to stand long. Manufacturers sometimes recommend steeping coconut cake in water, but this is hardly necessary when the animals are receiving quantities of roots.

Dairy Cows.—Both coconut cake and palmnut kernel cake have been used in Germany, principally for dairy cows, and are said to have a favourable effect on the quantity and quality of the milk fat. This characteristic appears to depend on the special nature of the fats in the two cakes.

Up to 5 lb. per head per day may be fed in the case of palmnut kernel cake and up to 4 lb. in the case of coconut cake. Larger quantities of the cakes than these have, however, been fed to dairy cows without any ill effects. The larger quantities are liable to induce excessive hardness in the butter, while serving to correct the effect of foods which give rise to softness in butter. Small amounts would probably prove useful in warm weather, when difficulty is experienced

in making firm butter. It is important that the cakes should not be rancid, since, if this is the case, the milk and butter produced are likely to have a bad flavour.

According to Pott the limits of the favourable effect on butter production appear to be reached in the case of palmnut kernel cake when $2\frac{1}{2}$ lb. are fed per head per day, but Kellner (1911 report) doubts whether smaller quantities than 5 lb. per head per day of palmnut kernel cake would have any effect on the fat content of the milk.

Recent English experiments on the feeding of coconut cake to dairy cows have been conducted at the South-Eastern Agricultural College, Wye, and at the Midland Agricultural and Dairy College. In the Wye College experiment, the quantity of coconut cake fed reached 6 lb. per head per day. In the Midland College experiment the addition of 5 lb. per head per day of coconut cake to the basal ration of shorthorn cows was compared with $4\frac{1}{2}$ lb. of linseed cake. The total milk yields during a fortnight were 2,472 lb. from linseed cake, and 2,429 lb. from coconut cake. The live-weight increase, however, was greater in the case of coconut cake, while the butter obtained from this food was firmer and better flavoured than that from linseed cake. The results were financially in favour of coconut cake, "this cake at £6 15s. per ton appearing to be well worth consideration when linseed cake is more than £9 per ton."

In a comparison between butter from coconut cake feeding and linseed cake feeding it was observed that the former butter had better keeping properties than the latter. No very great differences were shown in the flavour and texture of the two lots of butter. The coconut cake butter had, as a rule, a firmer and less oily texture and a better flavour.

Palmnut kernel cake was recently compared with decorticated cotton cake in an experiment at the Lancashire County Council Farm at Hutton. It was concluded that palmnut kernel cake could be recommended as a safe food for milch cows, although it was not more profitable to feed it at £5 2s. 6d. per ton than decorticated cotton cake at £8 12s. per ton. No difficulty was experienced in getting the cows to eat 7½ lb. per head per day of palmnut kernel cake when this amount was gradually worked up to; but this amount was large, and better results might have been obtained had the food been fed as only part of the cake ration. Even the large quantity of palmnut kernel cake fed had no undesirable effects on the butter produced.

The following daily rations containing coconut cake or palmnut kernel cake might be tried by dairy farmers :

I. (Approximate Cost 1s. 0½d.)	II. (Approximate Cost 1s. 2d.)
42 lb. swedes or mangolds.	28 lb. swedes or mangolds.
5 „ hay.	15 „ hay.
14 „ straw.	7 „ straw.
4 „ coconut cake or palmnut kernel cake.	2 „ coconut cake or palm-nut kernel cake.
3 „ dried grains.	2 „ undecorticated cot- ton cake.
2 „ bran.	3 „ dried grains.
	3 „ bran.

Fattening Cattle.—At the prices which prevailed in Germany before the outbreak of war, both coconut and palmnut kernel cake would seem to have been

found less suitable for fattening cattle than were several other concentrated foods.

An experiment carried out by the Edinburgh and East of Scotland College of Agriculture (Report XXVII), in which the addition of 4 lb. of coconut cake per head per day to the basal ration was compared with 4 lb. of linseed cake, showed the average daily increase from coconut cake to be 1.91 lb. per head compared with 2.25 lb. from the linseed cake. Taking into account the respective manurial values,¹ the conclusion was reached that when the price of good average linseed cake is £9 per ton, the value of coconut cake for fattening purposes is £6 1s. 8d. per ton.

Pigs and Sheep.—Although these animals eat coconut and palmnut kernel cakes very readily, and good results have been obtained in Germany from their use, especially in the direction of obtaining a very firm bacon, they have been found on the whole too expensive when compared with other concentrated foods for fattening pigs and sheep. The foods in question are recommended, however, in Germany, for suckling sows and ewes.

Horses.—Both kinds of cake or meal are recommended in Germany for replacing part of the oats in the ration, especially in the case of horses with a weak digestion; 1 lb. to 2 lb. of either may be used for this purpose. Coconut meal was tried about twenty years ago by the French Ministry of War for ten cavalry horses, part of the oats ration being replaced for four weeks by coconut meal. Horses fed on

¹ The manurial values of Hall and Voelcker for the different cakes are as follows, per ton :—Coconut cake, 34s. 7d.; palmnut kernel cake, 22s. 11d.; decorticated cotton cake, 64s. 9d.; undecorticated cotton cake, 37s. 1d.; linseed cake, 44s. 4d.

oats made an average loss of 13 lb., while those fed on oats and coconut meal gained $7\frac{1}{2}$ lb. There was no difference in the capacity of the two lots for work, and it was stated that the substitution of the coconut meal would have reduced the cost of feeding by 50 francs (£2) per horse per annum.

Conclusions

1. Palmnut kernel and coconut cakes or meals are valuable foodstuffs, particularly for milch cows when they can be obtained of good quality at a price which compares favourably with the prices of such feeding stuffs as linseed cake and cotton cake. They are also useful for replacing oats for horses, but are probably of less value for fattening bullocks, sheep and pigs.

2. Farmers should buy under guarantee as to analysis, paying special attention to the percentage of oil, fibre, albuminoids and carbohydrates. They should insist on fresh, well-made cake, and should not buy more than a three months' supply.

NOTE.—Further information respecting copra and palm kernels will be found in Nos. 3 and 4 of the *Bulletin of the Imperial Institute* for 1914 (London: J. Murray).

February, 1915.

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